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FREQUENCY RESPONSE OF THE TELEMETERED SEISMIC SYSTEM OF THE ISTITUTO NAZIONALE DI GEOFISICA, FROM THE SEISMOMETERS TO THE DIGITAL ACQUISITION SYSTEMS

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Abstract

A computer code for the automatic analysis of the transfer functions of the Italian Telemetered Seismic Network run by the "Istituto Nazionale di Geofisica" has been operating since 1991. A dedicated software was designed to perform fully automatic calibration analyses of the digital signals. In this paper we describe the signals used for the calibration and the interactive and batch procedures designed to obtain calibration functions in automatic mode. By using a steady-state method we reach a high degree of accuracy in the determination of both the frequency and amplitude of the signal. The only parameters required by this procedure are the seismometer mass, the calibration-coil constant and the intensity of the current injected into the calibration coil. The paper includes a general description of the designing criteria, and of the hardware and software architecture, as well as a report of the system performance during a period of two years of operation. Finally, appendix *A* shows the best calibrations available to date.

Introduction

The progress in computing resources often results in an improvement of the application performances of seismic instrumentation. The main purpose of the automatic procedure described in this paper is the real time monitoring of proper functioning and set up of the seismic stations.

All the stations in the network are equipped with S-13 Teledyne Geotech short period seismic sensors. The main characteristics of these seismometers are natural frequency of 1 Hz, high output level, small size and sturdiness. Since 1980 a large number of stations have been added to the Italian seismic network, which now includes 77 stations. Most of the sensors have been in operation for 10 years. For this reason the calibration functions could now be different from those reported by Teledyne Geotech for factory-new instruments.

The Istituto Nazionale di Geofisica (ING) technicians perform tests and calibration operations periodically on the Italian Telemetered Seismic Network (*ITSN*) stations. As a first step they apply a steady-state method which consists in measuring the frequency response for discrete harmonic frequencies injected into the calibration coil. Secondly they calculate the transfer function for equally spaced data using a least squares method by weighting the frequencies that are less affected by noise. The parameters required to determine the transfer function are the mass, the calibration coil constant, and the current injected into the calibration coil. It should be stressed that this method can be directly applied to find the transfer function of any system equipped with a calibration coil.

The software procedure was specially designed to require no modifications when the characteristics of the applied signal change. Furthermore, with this procedure it is possible to obtain the response of the complete system, from the ground motion to the final recording. The system includes different electronic components such as a transducer, amplifiers, telemetry sections and filters. Thanks to this procedure, the transfer function is promptly and automatically determined in the ING data acquisition center located in Rome. The data resulting from the analysis are used to test the correct functioning of the stations. An automatic calibration procedure has many advantages. In particular, it performs the acquisition and automatic calibration of the transfer functions, and it allows a high precision together with reduced working times.

Description of the network architecture

The overall architecture of the ITSN has been described in detail by *De Simoni and Di Giovambattista* (1988). What follows is only an overview of the main features of the network architecture for a better understanding of the problems involved in calibration operations.

The hardware of the network can be schematically represented by several distinct modules (block diagram in Figure 1). The centralized seismic network includes three main parts:
- Remote stations;
- Transmission system;
- Data acquisition and recording systems.

Each station is equipped with an *S13 Teledyne Geotech* short period vertical seismometer with a natural period of $1s$ and a critical damping of 70%, and a *Kinemetrics* electronic device which amplifies, band filters and modulates the signals. The signals are then transmitted over telephone lines or radio links to the ING data acquisition center where they are finally demodulated and recorded both on analog recordings (thermosensitive paper Helicorder drums) and on digital devices.

The transfer function of the analog recordings is different from that of the digital data. Data recorded on Helicorder are filtered with a $1Hz$ and 1 pole low pass.

The digital acquisition system [*Mele, 1993*] was developed in 1986 in the framework of a cooperation agreement between the United States Geological Survey and the ING. It runs on VAX 6000 and VAX 9000 computers. It includes a conversion system consisting of two *Preston A/D* converters with 128 channels; the analogue signals are converted to 12 bit plus sign samples rated at $50Hz$. The digital data are transmitted to a Vaxlab and to a Vax4200, where a pre-analysis is performed, and then to a Vax9000 and Vax6000 where they are processed and stored.

Calibration Method

The S-13 seismometers include a calibration circuit designed to receive special signals. This operation is equivalent to forcing the mobile mass of the sensor.

On the basis of the technical characteristics provided by the manufacturer we can determine the equivalent displacement of the ground due to the signal injected into the calibration coil. The output voltage produced by the seismometers during the calibration is telemetered similarly to the actual seismic signals and recorded in analogue mode on the drum recorders and on the digital acquisition systems. Digital voltage values are expressed in counts (1 count $\simeq 0.61mV$).

The steady-state calibration method allows the absolute value of the transfer function to be determined, that is, the magnification for each value of the frequency used to excite the sensor. A current $i(t)$ circulating in a calibration coil with a G calibration constant produces a force (on the seismometer mass) equal to

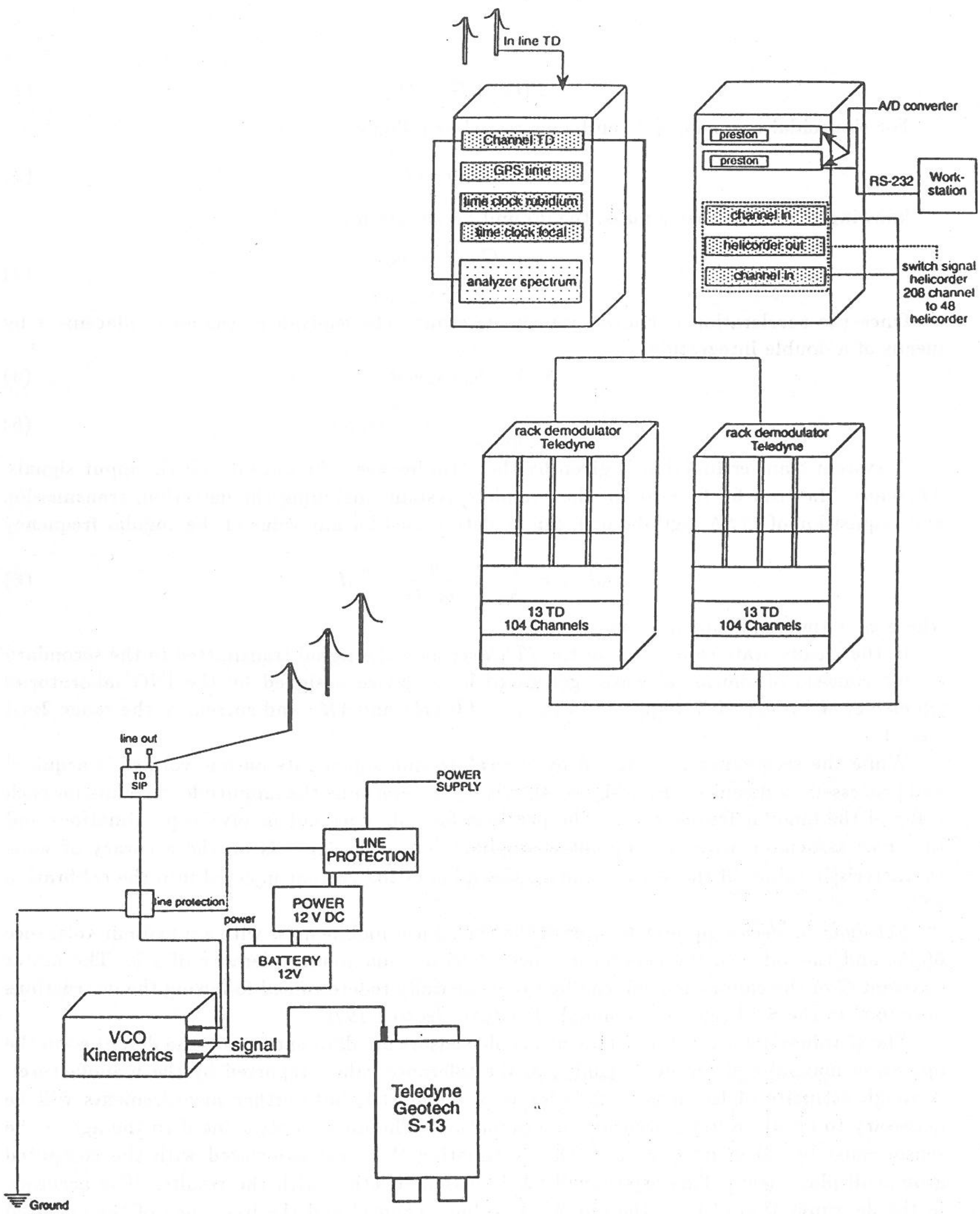

Figure 1: Network architecture.

$$F(t) = G \cdot i(t) \tag{1}$$

For sinusoidal currents, $i(t)$ can be expressed as follows:

$$i(t) = i_0 sen\omega t \tag{2}$$

knowing the seismometer mass, the ground acceleration is:

$$a(t) = \frac{G \cdot i_0 \cdot sen\omega t}{M} \tag{3}$$

Once the acceleration is known, we can determine the equivalent ground displacement by means of a double integration:

$$S(t) = S_0 \cdot sen\omega t \tag{4}$$

$$S(t) = -\frac{1}{M \cdot \omega^2} \cdot G \cdot i_0 sen\omega t \tag{5}$$

A system transfer function is given by the ratio between the output and the input signals. Therefore, the transfer function of the complete system (including the detection, transmission and acquisition of *ITSN* digital data), can be determined for any value of the angular frequency ω:

$$A(\omega) = \frac{y_0}{S_0} = \frac{y_0}{i_0 \cdot G} \cdot \omega^2 M \tag{6}$$

where y_0 is the amplitude in counts.

In the steady-state calibration of the *ITSN* sensors, the signal transmitted to the secondary circuit consists of sinusoidal waves generated by a device designed by the ING laboratories [*Romeo et al., 1985*] with frequency in the range $0.1Hz$ and $4Hz$ and current in the range $2mA$ - $1mA$.

While the seismometer is excited by the calibration signals, its output voltage is acquired and processed by means of the designed algorithm to determine the amplitude in counts for each value of the angular frequency ω. The previous formula does not involve approximations and the error associated with the computed amplification value depends on the accuracy of some characteristic values of the sensors and on the value of the current injected into the calibration coil.

Teledyne Geotech supplies the value of the transducer mobile mass with a maximum tolerance of 1% and the value of the generator constant with a maximum tolerance of 2%. The motor constant G of the calibration coil can be experimentally redetermined following the instructions described in the S-13 reference manual [*Teledyne Geotech,1976*].

The G values determined for some of the old sensors are different from those described in the operation manual and are not included in the tolerance values reported by the manufacturer. A rough estimate of the maximum error is of $0.008N/A$, but further measurements will be necessary to obtain a more accurate determination. The uncertainty related to the age of the sensor must be taken into account when estimating the error associated with the computed ground displacement. This aspect will be discussed together with the results. The accuracy in the determination of both the amplitude values (counts) and the frequency of the acquired calibration signals is another fundamental factor in the estimate of the error associated with the complete amplification value. These values, which are determined based on the parameters assumed in the algorithm, will be discussed later.

Table 1 contains the values of the parameters used in equation 6 with the associated tolerance, while Table 2 contains the errors associated with the values estimated by the procedure.

	Symbol	Value	Tolerance
Inertial mobile mass	M	* $5Kg$	1%
Calibration coil-Motor constant	G	* $0.1975N/A$	$0.002N/A$
Calibration current	i_0	** $2mA$	5%
	$\frac{i_0}{2}$	** $1mA$	5%

Table 1: Values of the parameters used in equation (6) with associated tolerance.
* *S-13 Operation manual [1976].*
** *Romeo et al. [1985].*

	Symbol	Relative error	Error on the mean value
Amplitude (counts)	y_0	$\Delta Y_0 = 4.5\%$	$\Delta y_0 = \frac{\Delta Y_0}{\sqrt{2N}} = 0.3\% \div 1.9\%$
Frequency (Hz)	ω	$\Delta\Omega = 4.5\%$	$\Delta\omega = \frac{\Delta\Omega}{\sqrt{2N}} = 0.3\% \div 1.9\%$

Table 2: Errors associated with variables of equation (6). The relative error depends on the maximum variation accepted around the mean value, computed on $2N$ half periods contained in the window T_{rec}, where $N = T_{rec} \cdot \omega$ and $T_{rec} = 27s$; the error on the mean value depends on the package frequency, and is referred to $\omega = (0.1 \div 4.0)Hz$.

Algorithm for the calibration analysis

We used the steady-state method to identify transfer functions of the seismograph system. Our goal was to develop a computer algorithm for correcting theoretical *ITSN* transfer functions. This method consists in measuring frequency responses for discrete harmonic frequencies across the system passband and identifying the corresponding transfer function [*Mitronovas and Wielandt, 1975*]. This is a long procedure to follow but it is insensitive to nonlinearities and to noise. The algorithm used in the automatic procedure was designed to compute the amplitudes in counts and the period in seconds for each set of monochromatic signals injected into the calibration coil. The procedure is based on a window moving on the digitally acquired data: the mean amplitude and period are computed for each monochromatic set of signals. The window length is set accordingly. A monochromatic set of signals is identified by performing a test based on the permanency of the frequency and amplitude within an assigned tolerance from the mean value. The tolerance is determined taking into account the fluctuations due to the telemetry system. The mean of the extreme values of the sinusoidal signals inside each moving window is computed in connection with the mean of the associated periods. The quality of the acquisition is evaluated by means of a simple pre-analysis based on the following conditions: the data are accepted if the extremal values differ from the mean values by less than 4.5%; the same tolerance is assumed for the periods. The amplitude of the window (approximately 27 seconds) was set on the basis of the duration of the monofrequency package (about 31 seconds) and of the attenuation time of the exponential factor (1.5 seconds maximum). The shift of the starting value of the window is assumed to be approximately equal to $\frac{2}{3}$ of the difference between the duration of the monofrequencies and the window length. These values represent a compromise between the running time and the number of recognized monochromatic packages transmitted to the calibration coil (usually 13 over 15). The error associated with the estimate of the amplitudes and periods was considerably reduced by assuming the mean value for each mobile window. Within the examined frequencies we used from 4-8 to 100-200 available values depending upon the analyzed frequency. The algorithm includes a filter used to reduce the high frequency noise when dealing with low frequencies. This filter consists of a mean of 1 second on a window with a shift of 1 sample. It does not introduce perceptible signal distortions for frequencies lower than $1Hz$. The software was designed to require no modifications if the device used to generate the sinusoidal current should change. In particular, changes in the number of monofrequency packages transmitted to the calibration coil with the only restriction that the difference between the frequency of two consecutive packages be greater than 5%.

Computer Program

The system software was entirely written in *FORTRAN* language and runs on a VAX computer. The flowchart is shown in Figure 2. As we mentioned before, this procedure is used for the calibration of the complete system, including the receiver, telemetry and acquisition system.

The procedure was designed according to the following requirements:

- Applicability to the routine calibration of an arbitrary seismograph equipped with a calibration coil.

- Use of all the previous information on the transfer properties of the investigated system (zeroes, poles, scale factor of the theoretical transfer function and assumed accuracy of the individual parameters) [*Di Maro,1993*].

- Automatic quality check.

The procedure is divided into two main parts: the first regards the acquisition and analysis of the polarity test, and the second deals with the acquisition and analysis of the calibration function. It can be activated by a command procedure that assigns the true logical names and the necessary privileges to perform the calibration acquisition. Furthermore, it can run in automatic or interactive mode and can be activated in all the acquisition systems running at the ING. The polarity test only requires typing a command that allows the acquisition and display of the corresponding output signal.

The procedure for the acquisition and analysis of the calibration signal is more complex. All the modules are schematically represented in Figure 3. This procedure is activated by typing the command *"Calibration"* and specifying the station code. The data acquired in binary system are converted and subsequently the amplitudes for each monochromatic wave are computed using the algorithm described above. The calibration function is automatically plotted on a laser printer. Figures 4 through 7 show examples of the automatic output. A simple comparison between the theoretical and the experimental calibration functions allows us to verify that the station works properly.

As we mentioned before, the automatic procedure may stop working depending on the results of the check performed on the acquired data. In case of high seismic or electronic noise, the automatic procedure will stop and the error message *"divided by zero"* will be displayed. This error occurs in the *Taranew* block when all of the threshold levels assumed in the algorithm are exceeded. Another interruption of the automatic procedure can occur in case of acquisition of a wave with a period longer than the mobile window. In this case the error message displayed is *"bad search window length"*. This error usually occurs when electronic disturbances are recorded,

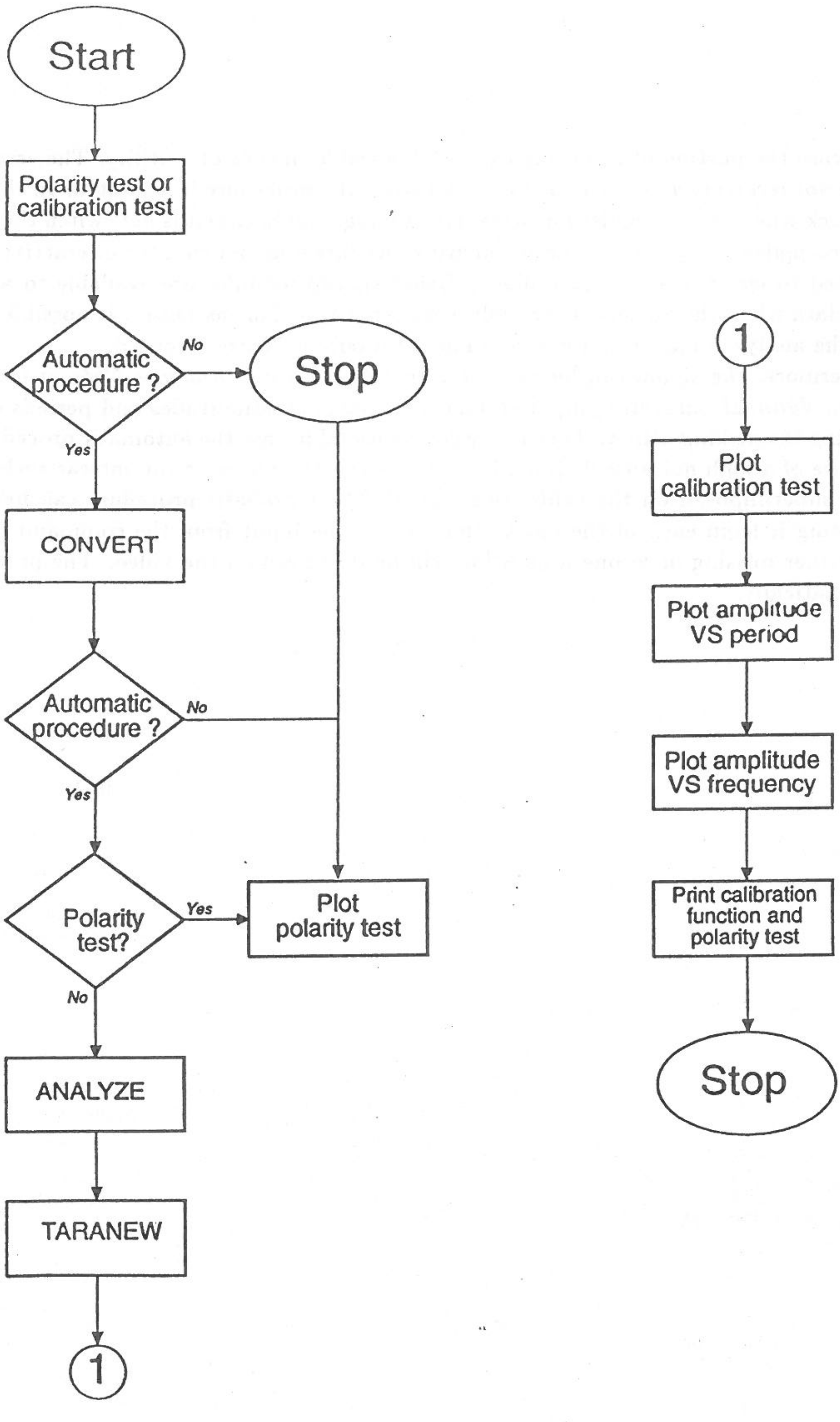

Figure 2: Flowchart of proposed calibration procedure.

in which case the portion of recording can be removed by means of a utility. The error message *"detect is not receiving data"* may be displayed when the procedure is activated. In this case one should check whether the acquisition system is running, and in case it is not switch the procedure to another acquisition system. If the automatic procedure does not run, the interactive procedure can be used to enter each separate block. Other special modules are available to analyze the acquired data when the automatic procedure does not run. For instance it is possible to cut out parts of the analyzed data if noise or any kind of interference are recorded.

Furthermore, the signal can be converted to *SAC, Seismic Analysis Code of the Lawrence Livermore National Laboratory* input standard format, and amplitudes and periods can be obtained using the picking utility. This utility is very useful in case the automatic procedure cannot run because of a high noise level. Indeed, in some cases the operator can interactively recognize the noise superimposed on the calibration signal. The automatic procedure can be optimized by activating it from each of the blocks that accept the input from the command line. If the input is either missing or wrong a question will be displayed on the video. The procedure will run automatically.

PROGRAM	FUNCTIONING
POLARITY	Polarity test remote acquisition (binary format)
CALIBRATION	Calibration test remote acquisition (binary format)
CONVERT	Conversion from binary output of polarity and calibration test to ascii format (standard ING format)
ANALYZE	Analysis of amplitude (counts) and period for each monochromatic signals
TARANEW	Compute the RSNC transfer function (amplitude (counts/mm)) by means of the direct calibration method
GRAFPOL	Plot the polarity test acquired signals
GRAFCAL	Plot of amplitude (counts) vs period for the two calibration signals
GRAF_PER	Plot the amplitude (counts/mm) vs period of the calibration test
GRAF_FREQ	Plot the amplitude (counts/mm) vs frequency of the calibration test

Figure 3: Modules for automatic and interactive calibration analysis.

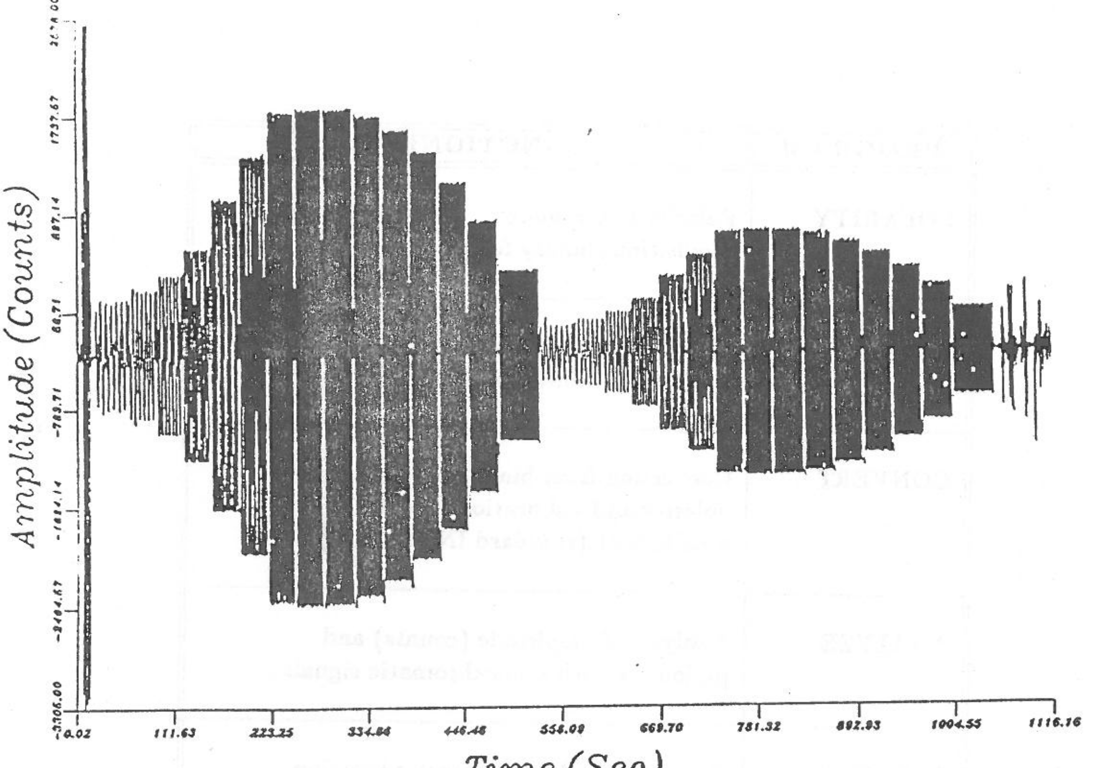

Figure 4: Example of the calibration signal injected into a sensor calibration coil and digitally acquired at the ING data center.

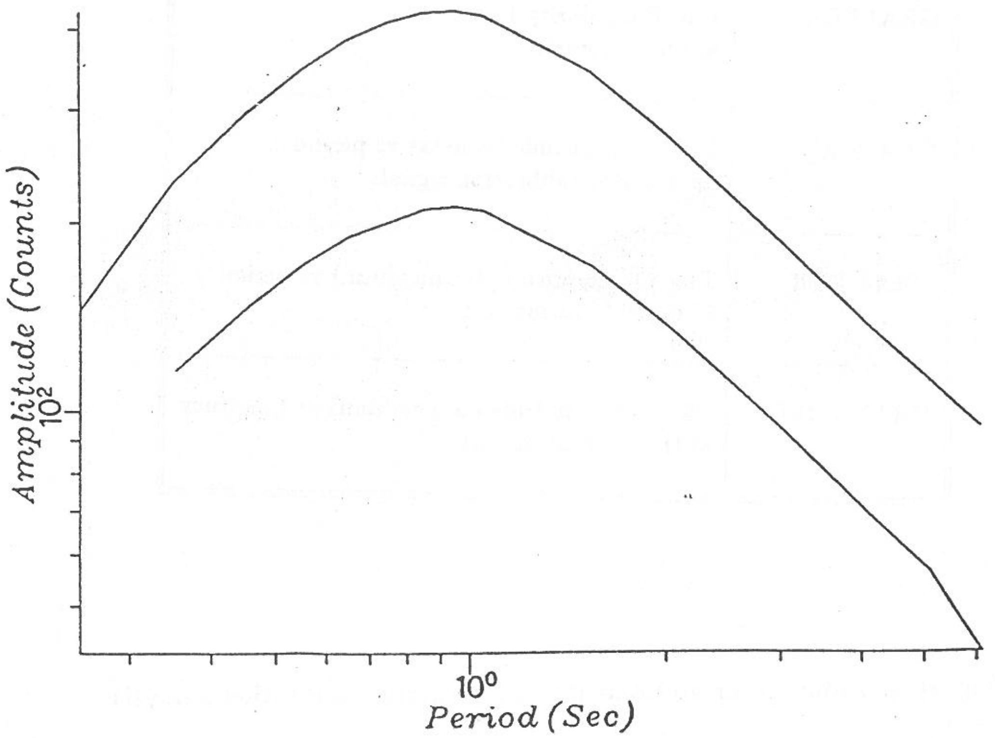

Figure 5: Plot of amplitude versus period for the two calibration signals sent into the sensors with current i_0 and $i_0/2$.

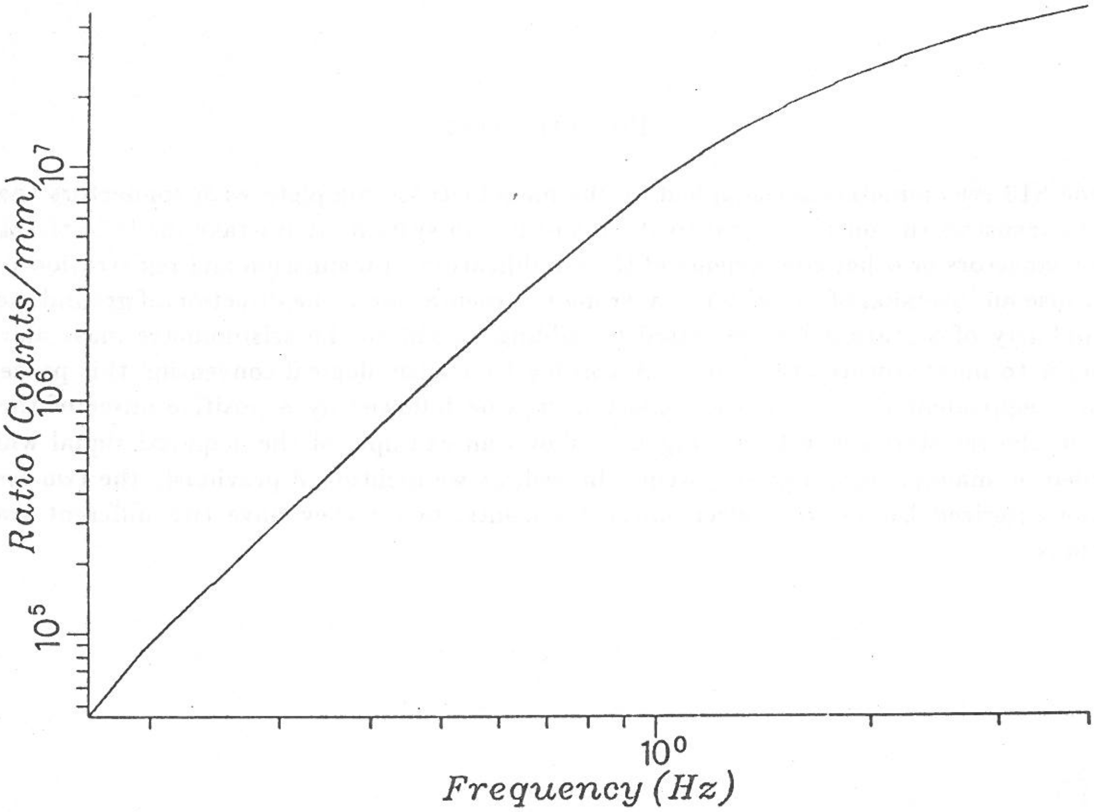

Figure 6: Plot of amplitude versus frequency.

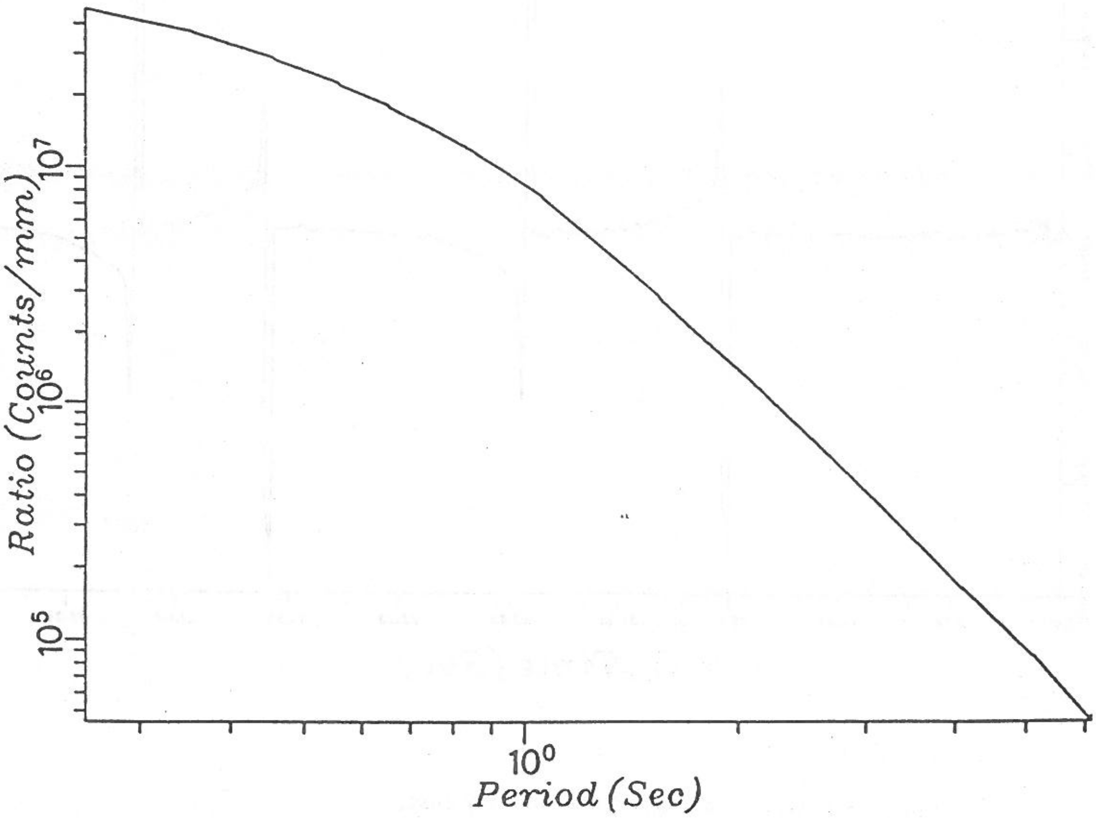

Figure 7: Plot of amplitude versus period.

Polarity test

The S13 seismometers are supplied by the manufacturer complete with connectors that are used to transmit the output signal to the transmission system. A mistake made in the link of these connectors or other components of the amplification, transmission and registration system may cause an inversion of polarity i.e. a wrong representation of the direction of ground motion. The polarity of a station can be tested by adding weight to the seismometer mass and thus forcing it to move towards the Earth. According to a seismological convention this procedure, which is equivalent to an Earth lift, must always be followed by a positive onset of the first pulse in the registered waveform. Figure 8 shows an example of the acquired signal which is recorded in analogue and digital systems. Indeed, as we mentioned previously the two systems are characterized by different electronic components, hence they have two different transfer functions.

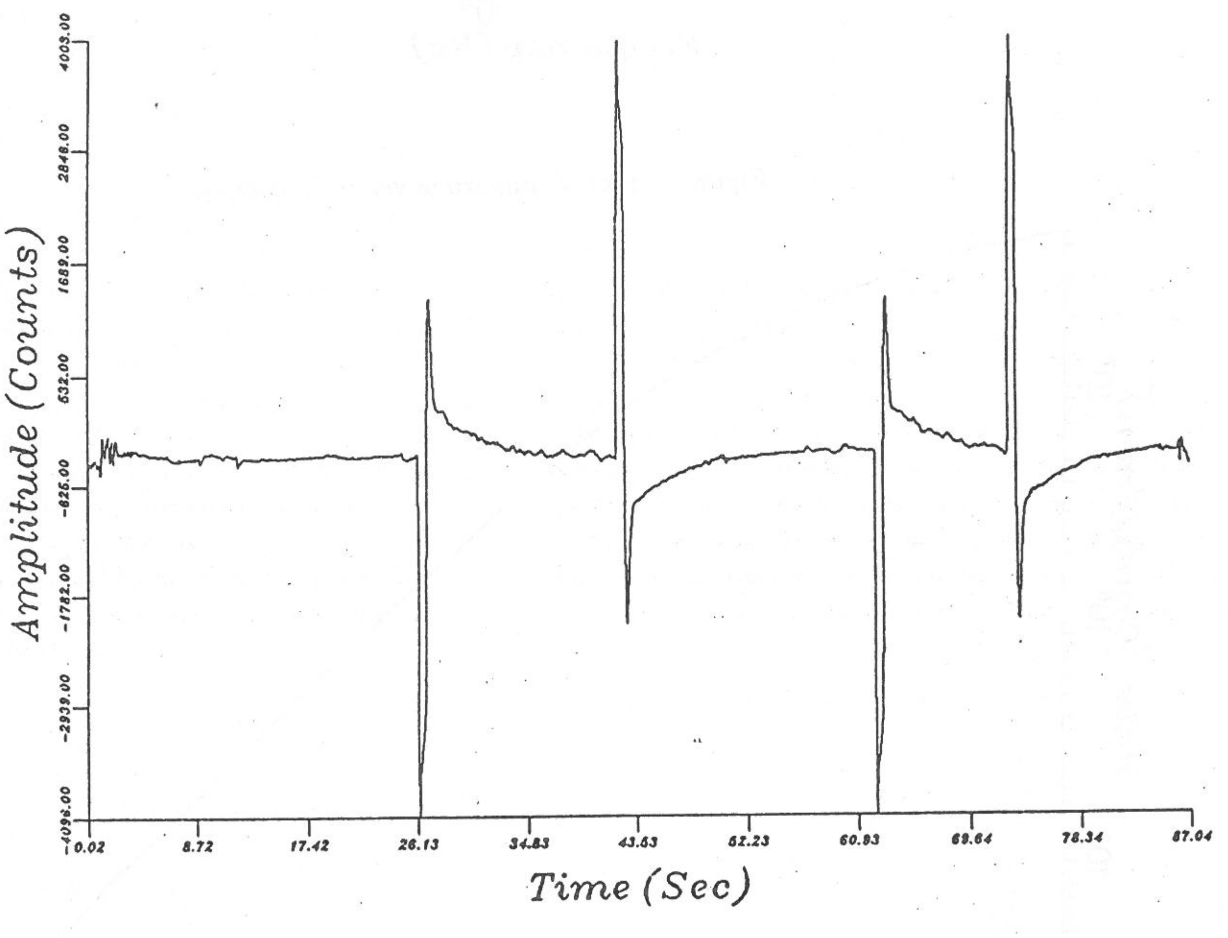

Figure 8: Polarity test.

Results

The calibration function of the *ITSN* is given using either *poles* and *zeroes* or *frequency-amplitude* formulations.
The standard format for *GSE (Group of Scientific Experts)* waveform data exchange has been followed [*Source Book for International Seismic Data Exchange, 1989*] for both the representations. Poles and zeroes are defined so that the complex instrumental transfer function $T(w)$ relating ground displacement $G(w)$ to the recorded digital seismogram $S(w)$ is

$$S(w) = T(w)G(w) \tag{7}$$

where

$$T(\omega) = \frac{C\prod_{i=1}^{nzero}(s - zero_i)}{\prod_{i=1}^{npole}(s - pole_i)} \tag{8}$$

w is angular frequency ($= 2\pi f$ where f is frequency in Hertz) and $s = jw$.
The absolute value or modulus of $T(w)$ gives the number of units of ground motion in *nanometers (nm)* corresponding to one digital count at frequency w.
The polynomials are specified by their roots. The roots of the numerator polynomial are the instrument zeroes, and the roots of the denominator polynomial are the instrument poles. Because the polynomials have real coefficients, complex poles and zeroes will occur in complex conjugate pairs.

The scale factor C was computed from the period-amplitude data determined by the automatic procedure. In this application we have N samples of the preprocessed and non-equally spaced experimental response h_i. Poles and zeroes are taken as fixed, i.e. the inversion procedure does not alter them. To obtain the scale factor that gives the best fit of the experimental data, we compute for each value of the frequency the C_i value obtained from the ratio between the experimental and the theoretical value computed in (8) assuming that $C = 1$. The C_i values associated with frequencies that are less affected by noise are weighted more than the others. The minimum and maximum of the computed values are then determined, and starting from an interval ranging from $C_{max} + \delta C$ and $C_{min} - \delta C$ we compute the least-square fit with an ϵ increase of 1 count/nm. The C value for which we obtain the best fit of the experimental data is then assumed as the scale factor to determine equally-spaced values of the calibration function.

Table 3 contains a brief description of the station parameters, while Table 4 contains a sample of the calibration function given as poles, zeroes and the scale factor C obtained from the best fit on experimental data. This table includes all the parameters with which the transfer function can be computed with formula (8). Table 5 contains data computed as equally-spaced, assuming the C value obtained by the best fit. The calibrations reported in Appendix A are the best available to date, and will be updated as soon as more come to hand.

The limitations of the automatic calibration procedure are represented by the ratio of calibration signal amplitude to seismic background noise. Indeed, if the ground noise is too high the maximum value of amplitudes and periods of each monochromatic signal may differ from the mean value by more than 4.5%, thus preventing the automatic procedure from working.

Figure 9 shows some calibration functions of stations working at the same nominal amplification together with the theoretical transfer function. Comparing the theoretical transfer functions to those obtained for several stations having the same amplification shows significant differences between the experimental and theoretical amplifications. Using a standard transfer function to compute the Earth's displacement may result in large errors. The differences demonstrate that some seismometers and, more likely, other components of the transmission system are not ideal instruments and therefore cannot be represented by nominal parameters. In any case, the differences observed measuring the G value of the calibration coil were not sufficient to explain the large amplitude differences shown in Figure 9.

Station Description	
Station:	CAPRESE MICHELANGELO
Station Code:	CRE
Latitude:	$43°37'37.2''N$
Longitude:	$11°56'52.8''E$
Elevation:	1115 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	66 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	10/1983
Date off:	
Comments:	

Table 3: Description of the station parameters, including all the parameters required to compute the *ITSN* transfer function.

Station CRE
Short period response (poles and zeros)

```
CAL1 CRE

        6
     -0.1884        0.0
     -0.1884        0.0
     -4.769         -4.090
     -4.769         +4.090
     -31.4          +0.0000
     -31.4          +0.0000
        5
     -0.0           0.0
     -0.0           0.0
     -0.0           0.0
     -0.0           0.0
     -0.0           0.0
CRE, CENTRAL ITALY.
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
D(W)=C*(S-Z1)(S-Z2)...(S-Z6)/((S-P1)(S- P2)...(S-P5)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=1221.89 COUNT/(NM*SEC) NORMALSIZES SO THAT THE NUMBER OF NANOMETERS
   PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.
```

Table 4: Example of calibration data given as poles and zeroes and experimentally redetermined scale factor

Short Period Response Data CAPRESE MICHELANGELO 1992-1-14	
Frequency (Hz)	Amplitude (counts/nm)
0.1	0.007
0.2	0.060
0.3	0.204
0.4	0.475
0.5	0.899
0.6	1.484
0.7	2.216
0.8	3.062
0.9	3.978
1.0	4.923
1.1	5.864
1.2	6.778
1.3	7.653
1.4	8.484
1.5	9.268
1.6	10.009
1.7	10.706
1.8	11.363
1.9	11.982
2.0	12.566
2.1	13.115
2.2	13.633
2.3	14.120
2.4	14.578
2.5	15.007
2.6	15.410
2.7	15.788
2.8	16.140
2.9	16.469
3.0	16.774
3.1	17.058
3.2	17.320
3.3	17.563
3.4	17.785
3.5	17.990
3.6	18.176
3.7	18.345
3.8	18.498
3.9	18.635
4.0	18.758

Table 5: Equally-spaced values of *ITSN* transfer function computed by means of the calibration function procedure.

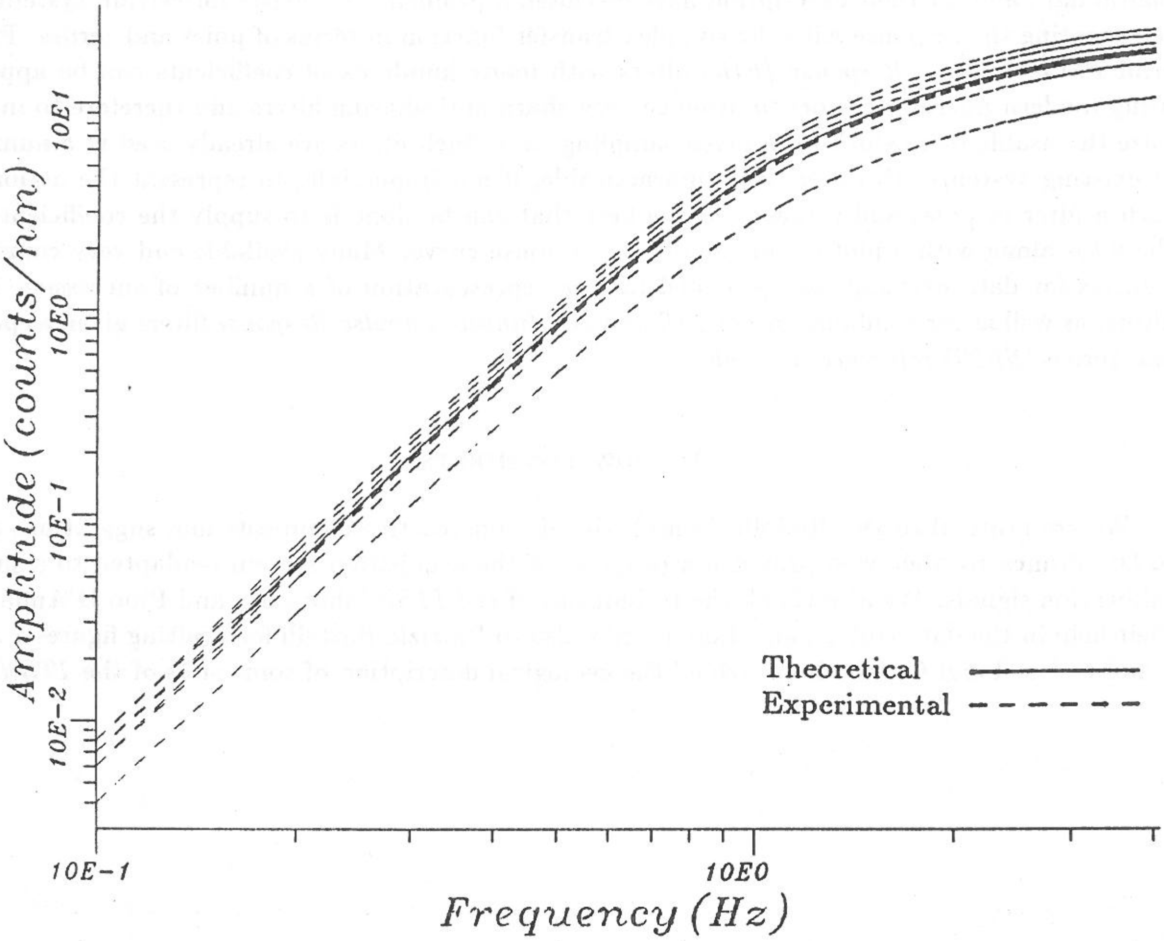

Figure 9: Calibration functions of stations working at the same nominal amplification.

Discussion

Although several aspects could be improved in a future version of the calibration operation, we still believe that a large amount of seismological work can now get started using the present system. In particular, the procedure we applied could be improved using the G value computed for each sensor. As we mentioned before, when we apply calibration pulses to the calibration coil and use the nominal value of the generator constant to determine the equivalent movement of the displacement, we introduce an error in the calculated response due to the effect of a change of the G value as a consequence of the magnet ageing.

The efforts of *Federation of Digital Seismograph Networks* to reach a standard format for digital data and for their description have disclosed a problem that exists for certain systems in representing the response with the complex transfer function in terms of poles and zeroes. Powerful *Finite Impulse Response (FIR)* filters with many hundreds of coefficients can be applied using modern microprocessors to produce very sharp anti-aliasing filters and therefore to maximize the usable bandwidth for a given sampling rate. Such filters are already used in a number of existing systems. However, it is impracticable, if not impossible, to represent the action of such a filter in poles and zeroes, and the best that can be done is to supply the coefficients of the filter along with a plot of the amplitude response curve. Many available and very common formats for data exchange are provided for the representation of a number of successive *FIR* filters, as well as for combinations of *FIR* and *IIR Infinite Impulse Response* filters given as poles and zeroes [*SEED reference manual*].

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References

B. De Simoni and R. Di Giovambattista (1988). Sviluppo della rete sismica nazionale centralizzata. *Proceedings of the 7th meeting G.N.G.T.S., 1577-1584.*

R. Di Maro (1993). Problematiche connesse con il calcolo della funzione di trasferimento dei sismografi in uso presso la Rete Sismica Nazionale Centralizzata dell'Istituto Nazionale di Geofisica. *ING Internal Report N. 551, Roma.*

GSE (1989). Source Book For International Seismic Data Exchange. *Paper N°167/Rev.1.*

F. M. Mele (1993). Elaborazione automatica di segnali sismici presso l'Istituto Nazionale di Geofisica. *Ricerche nel campo della sismologia e geodinamica negli anni 1990-1991*, Istituto Nazionale di Geofisica, Roma.

W. Mitronovas and E. Wielandt (1975). High-precision phase calibration of long-period electromagnetic seismographs. *Bulletin of the Seismological Society of America 65, 411-424.*

G. Romeo, Q. Taccetti, M. Tozzi (1985). Dispositivo di taratura per stazioni sismiche. *ING Internal Report N.498*, Roma.

SEED Standard for the Exchange of Earthquake Data. *Reference Manual.*

Teledyne Geotech (1976). Operation and maintenance manual portable short-period seismometer, model S-13. *STOCK NO.990-18300-98-01*, Texas.

CALIBRATION FUNCTIONS OF THE

ITALIAN TELEMETERED SEISMIC NETWORK

Istituto Nazionale di Geofisica

Appendix A

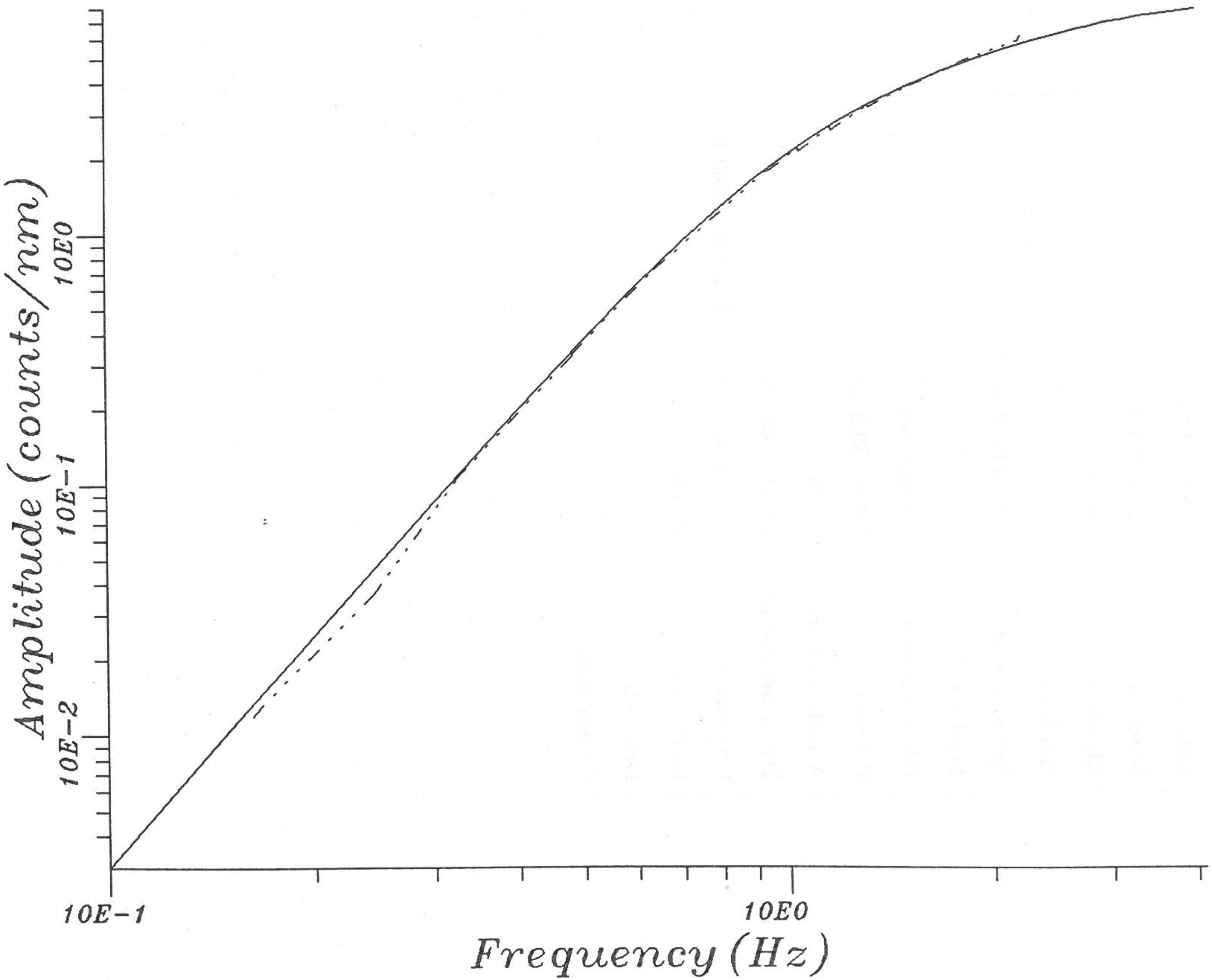
CALIBRATIONS LIST	
Station	**Date**
AZI	1992-06-16
BDI	1992-01-15
BDI	1992-07-29
CRE	1992-01-14
DOI	1991-05-21
DUI	1992-04-08
GIB	1991-09-18
GMB	1991-02-28
LVI	1992-02-03
MDI	1992-06-22
MGR	1992-08-06
MNO	1992-06-15
PZI	1991-04-23
RBL	1991-12-03
RSM	1991-12-05
SFI	1992-09-25
SGO	1992-01-27
SOI	1992-01-17
SOIN	1992-01-16
SOIE	1992-01-16
TDS	1991-11-05

LEGEND: Experimental ·····–·····–·····–

Equally spaced data ————

Station Description	
Station:	AVEZZANO
Station Code:	AZI
Latitude:	41°59′13.2″N
Longitude:	13°26′ 9.6″E
Elevation:	730 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	
Discriminator:	Kinemetrics
Filters:	0.030 - 30.0 Hz
Amplification:	60 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	10/1987
Date off:	
Comments:	

AZI Avezzano 1992-6-16



Station AZI
Short period response (poles and zeros)

CAL1 AZI

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

AVEZZANO, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=513.98 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

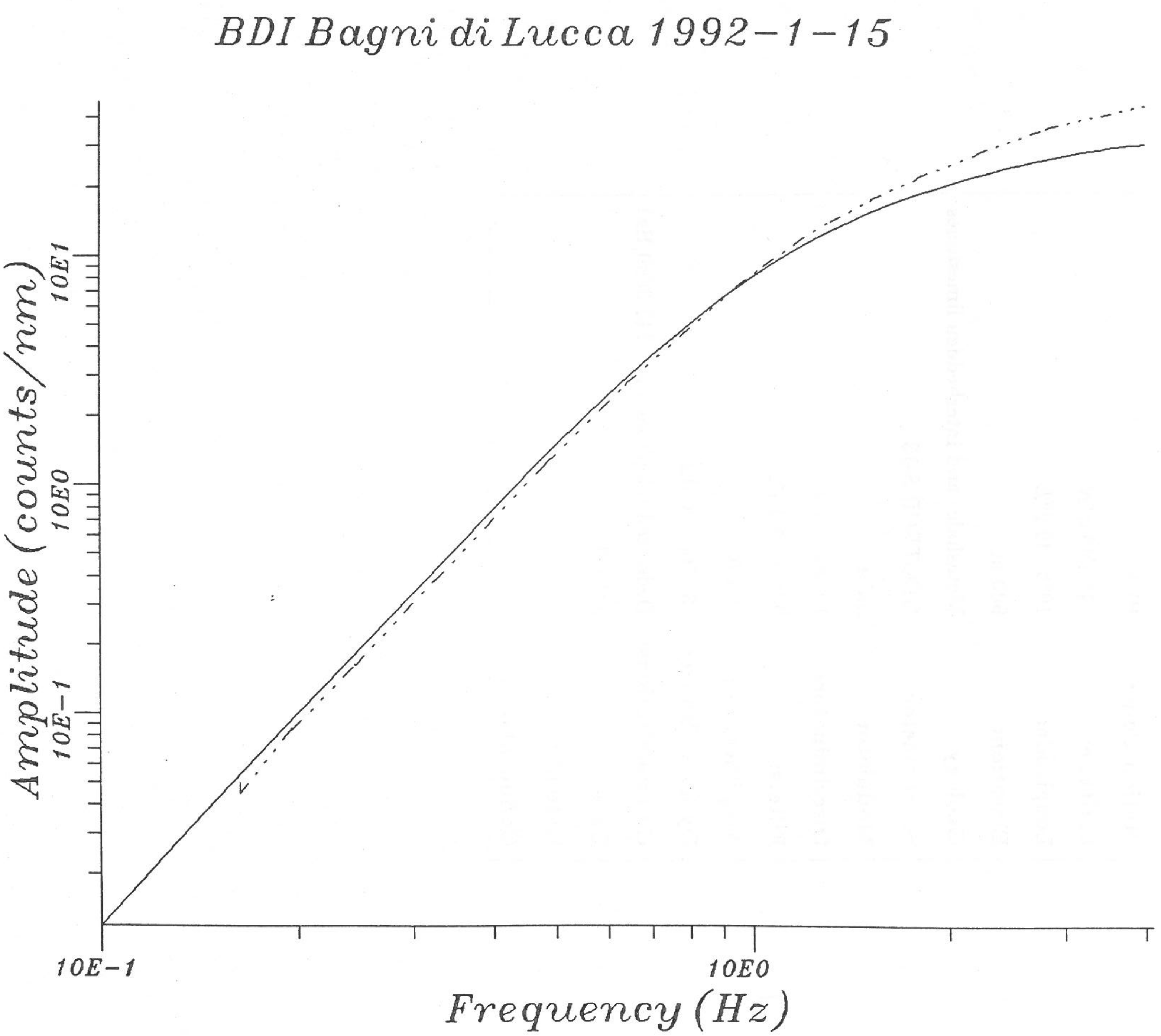
Short Period Response Data

AVEZZANO

1992-6-16

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.003
0.2	0.025
0.3	0.086
0.4	0.200
0.5	0.378
0.6	0.624
0.7	0.932
0.8	1.288
0.9	1.673
1.0	2.071
1.1	2.466
1.2	2.851
1.3	3.219
1.4	3.569
1.5	3.899
1.6	4.210
1.7	4.503
1.8	4.780
1.9	5.040
2.0	5.286
2.1	5.517
2.2	5.735
2.3	5.939
2.4	6.132
2.5	6.313
2.6	6.482
2.7	6.641
2.8	6.789
2.9	6.927
3.0	7.056
3.1	7.175
3.2	7.286
3.3	7.388
3.4	7.481
3.5	7.567
3.6	7.646
3.7	7.717
3.8	7.781
3.9	7.839
4.0	7.890

Station Description	
Station:	BAGNI DI LUCCA
Station Code:	BDI
Latitude:	44° 3′43.2″N
Longitude:	10°35′49.2″E
Elevation:	900 m
Geology:	Metashales and interbedden limestones
Seismometer:	GEOTECH S-13
Modulator:	Saba
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	72 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	9/1983
Date off:	
Comments:	


BDI Bagni di Lucca 1992−1−15
Amplitude (counts/nm)
10E1
10E0
10E−1
10E−1
10E0
Frequency (Hz)

Station BDI
Short period response (poles and zeros)

CAL1 BDI

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

BAGNI DI LUCCA, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=2038.33 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

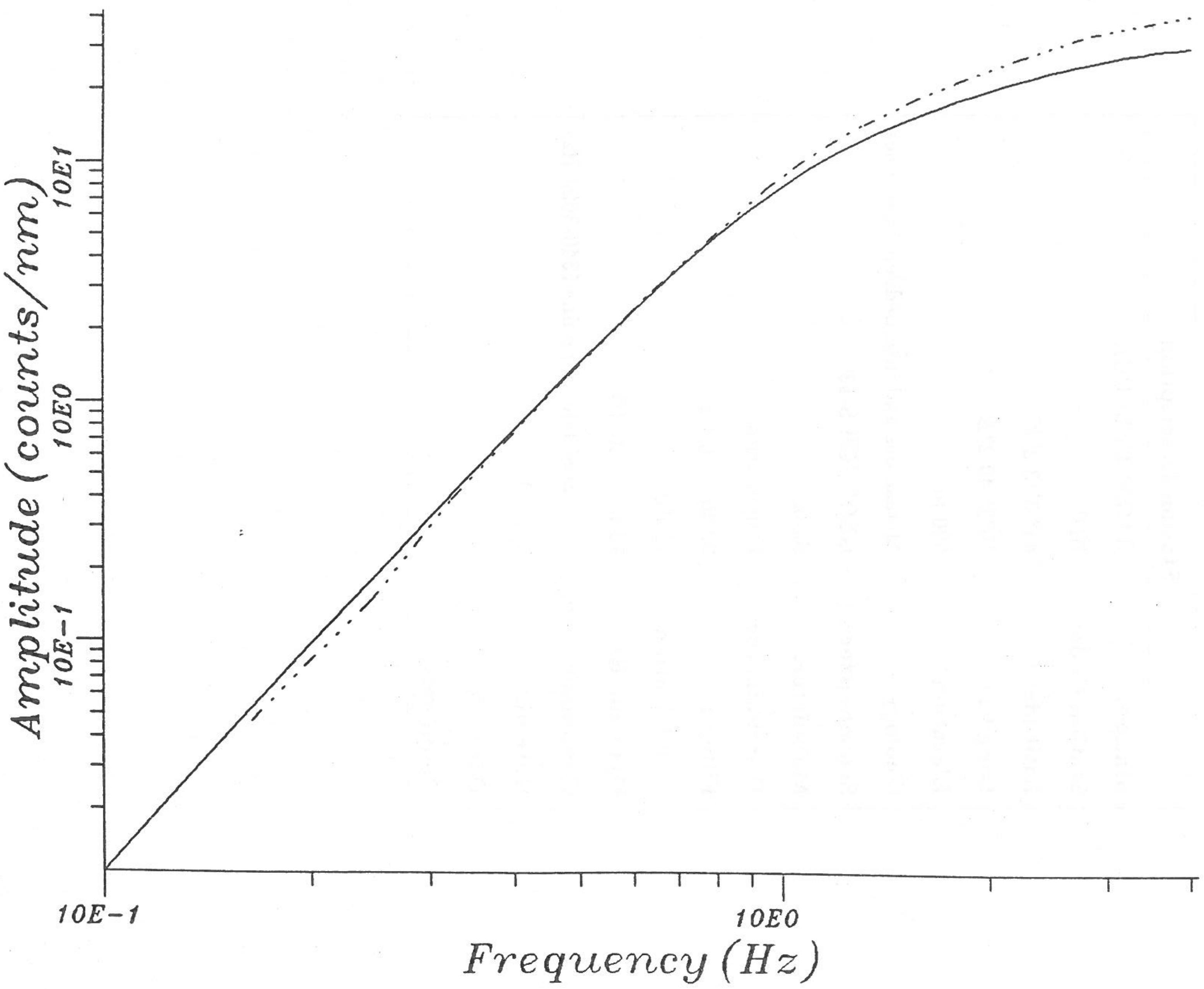
BAGNI DI LUCCA

1992-1-15

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.012
0.2	0.101
0.3	0.340
0.4	0.792
0.5	1.500
0.6	2.476
0.7	3.697
0.8	5.107
0.9	6.636
1.0	8.212
1.1	9.781
1.2	11.306
1.3	12.766
1.4	14.152
1.5	15.461
1.6	16.696
1.7	17.859
1.8	18.956
1.9	19.989
2.0	20.962
2.1	21.879
2.2	22.742
2.3	23.555
2.4	24.318
2.5	25.035
2.6	25.707
2.7	26.337
2.8	26.924
2.9	27.473
3.0	27.983
3.1	28.456
3.2	28.894
3.3	29.298
3.4	29.669
3.5	30.010
3.6	30.320
3.7	30.603
3.8	30.858
3.9	31.087
4.0	31.291

Station Description	
Station:	BAGNI DI LUCCA
Station Code:	BDI
Latitude:	44° 3′43.2″N
Longitude:	10°35′49.2″E
Elevation:	900 m
Geology:	Metashales and interbedden limestones
Seismometer:	GEOTECH S-13
Modulator:	Saba
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	72 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	9/1983
Date off:	
Comments:	

BDI Bagni di Lucca 1992-7-29



Station BDI
Short period response (poles and zeros)

CAL1 BDI

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

BAGNI DI LUCCA, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=1968.19 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER
DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

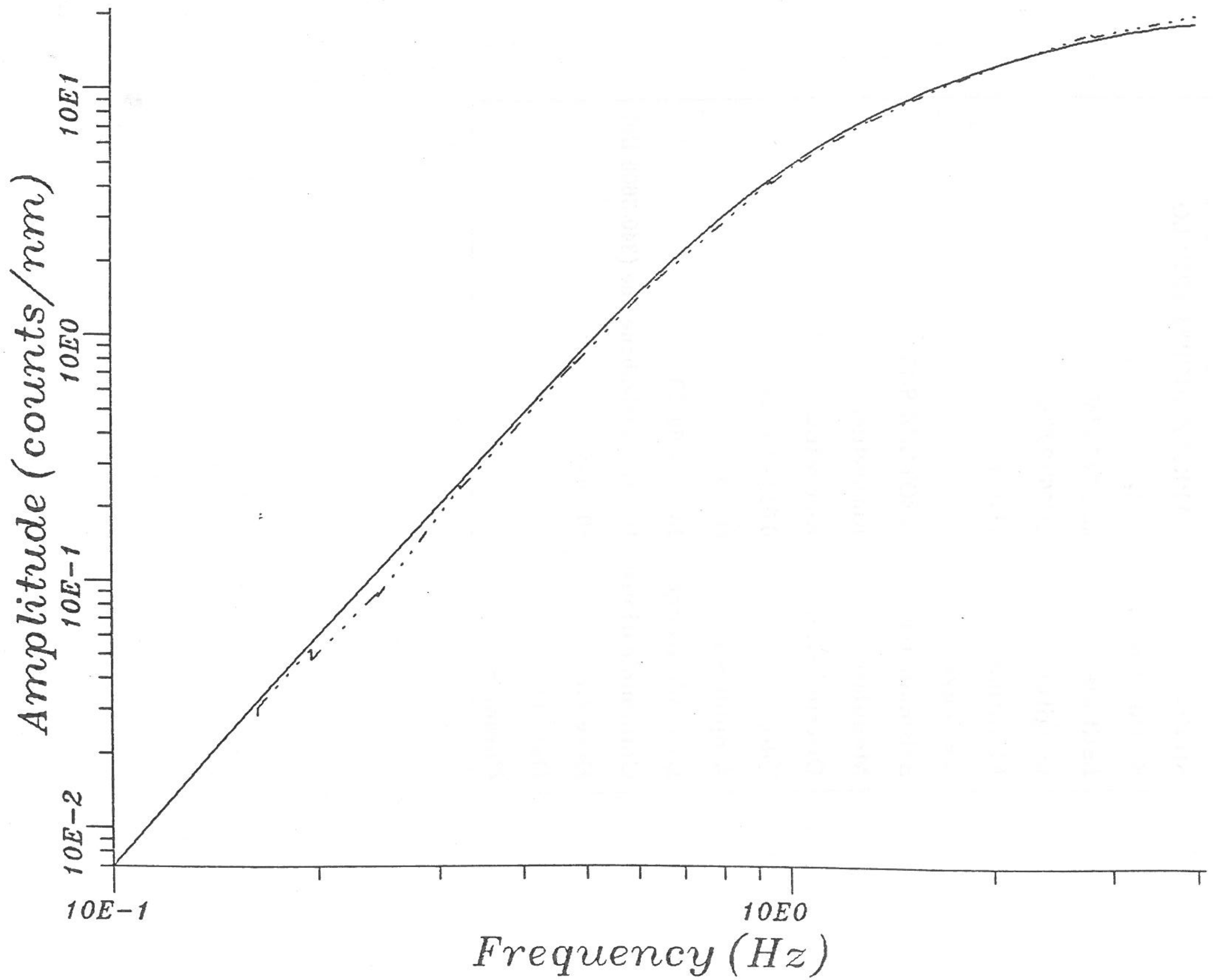
BAGNI DI LUCCA

1992-7-29

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.011
0.2	0.097
0.3	0.328
0.4	0.765
0.5	1.448
0.6	2.391
0.7	3.570
0.8	4.932
0.9	6.407
1.0	7.930
1.1	9.445
1.2	10.917
1.3	12.327
1.4	13.665
1.5	14.929
1.6	16.122
1.7	17.245
1.8	18.303
1.9	19.301
2.0	20.241
2.1	21.126
2.2	21.960
2.3	22.744
2.4	23.481
2.5	24.174
2.6	24.823
2.7	25.430
2.8	25.998
2.9	26.527
3.0	27.020
3.1	27.477
3.2	27.899
3.3	28.290
3.4	28.648
3.5	28.977
3.6	29.277
3.7	29.550
3.8	29.796
3.9	30.017
4.0	30.214

Station Description	
Station:	CAPRESE MICHELANGELO
Station Code:	CRE
Latitude:	43°37'37.2"*N*
Longitude:	11°56'52.8"*E*
Elevation:	1115 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	66 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	10/1983
Date off:	
Comments:	

CRE Caprese Michelangelo 1992–1–14



Station CRE
Short period response (poles and zeros)

CAL1 CRE

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

CAPRESE MICHELANGELO, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=1221.89 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

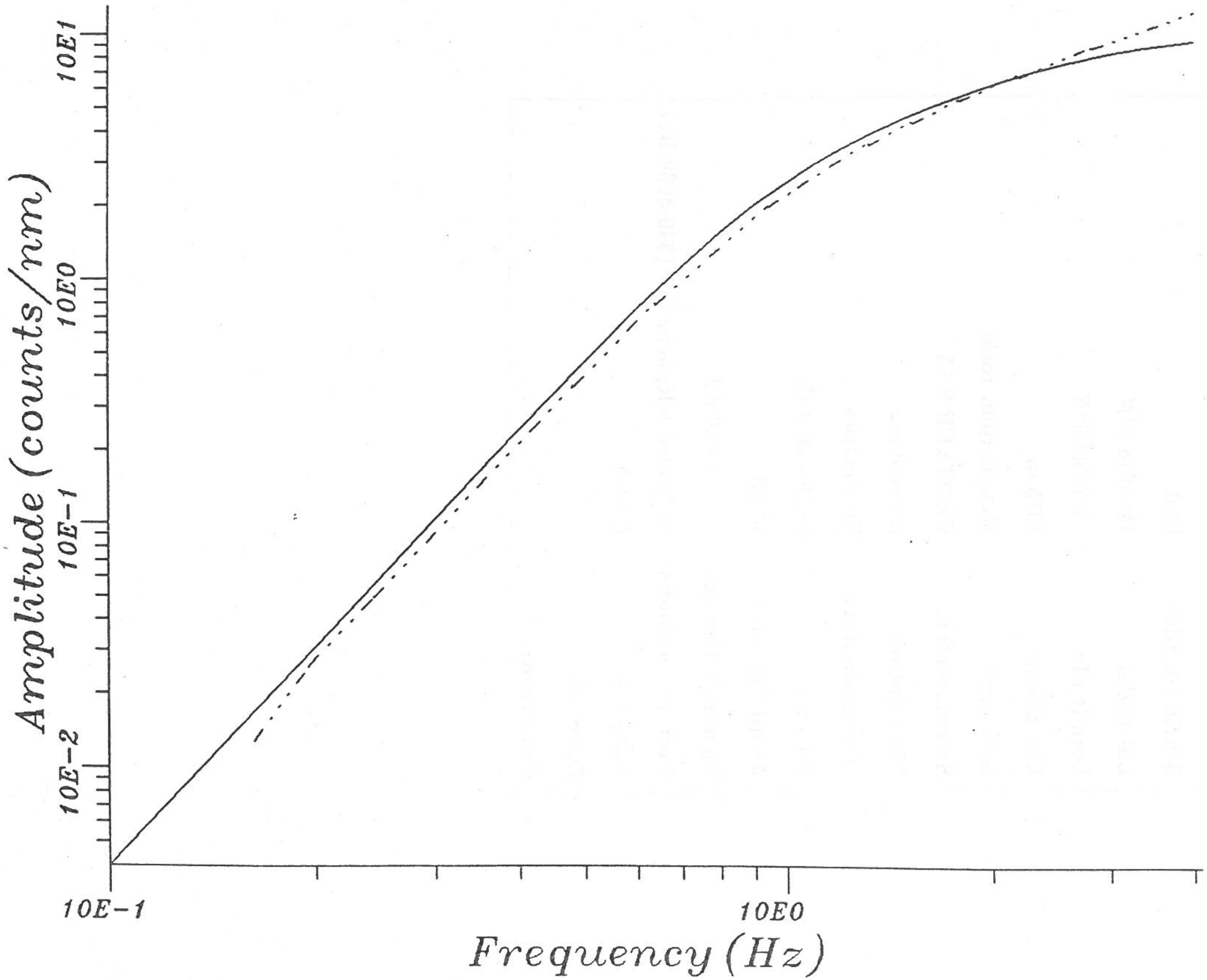
CAPRESE MICHELANGELO

1992-1-14

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.007
0.2	0.060
0.3	0.204
0.4	0.475
0.5	0.899
0.6	1.484
0.7	2.216
0.8	3.062
0.9	3.978
1.0	4.923
1.1	5.864
1.2	6.778
1.3	7.653
1.4	8.484
1.5	9.268
1.6	10.009
1.7	10.706
1.8	11.363
1.9	11.982
2.0	12.566
2.1	13.115
2.2	13.633
2.3	14.120
2.4	14.578
2.5	15.007
2.6	15.410
2.7	15.788
2.8	16.140
2.9	16.469
3.0	16.774
3.1	17.058
3.2	17.320
3.3	17.563
3.4	17.785
3.5	17.990
3.6	18.176
3.7	18.345
3.8	18.498
3.9	18.635
4.0	18.758

Station Description	
Station:	SAN DAMIANO MACRA
Station Code:	DOI
Latitude:	44°30′14.4″N
Longitude:	7°14′42.0″E
Elevation:	1015 m
Geology:	Metamorphic rocks
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 30.0 Hz
Amplification:	54 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	7/1985
Date off:	
Comments:	

DOI S. Damiano Macra 1991-5-21



Station DOI

Short period response (poles and zeros)

CAL1 DOI

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

SAN DAMIANO MACRA, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=623.93 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER
DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

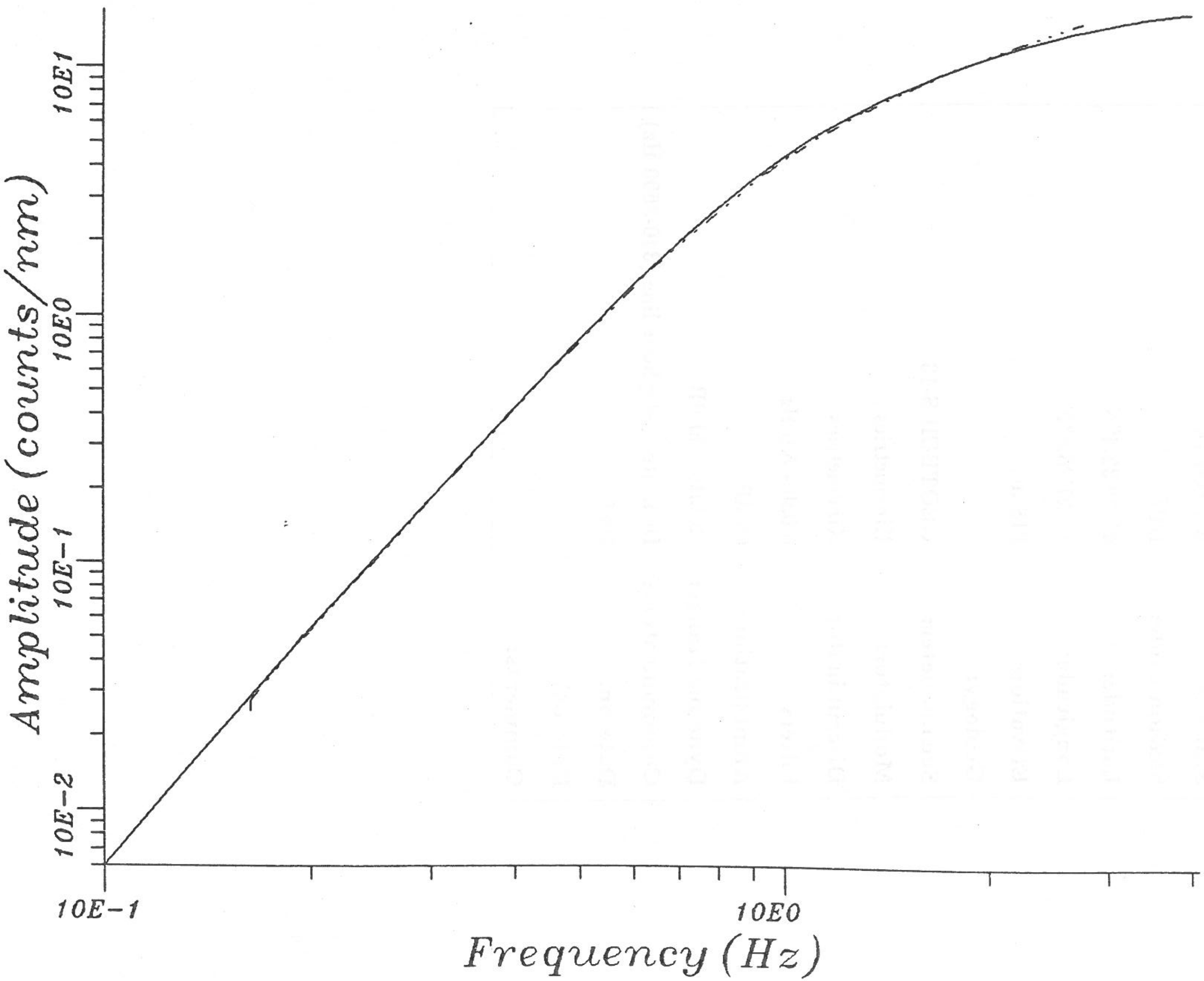
S. DAMIANO MACRA

1991-5-21

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.004
0.2	0.031
0.3	0.104
0.4	0.242
0.5	0.459
0.6	0.758
0.7	1.132
0.8	1.563
0.9	2.031
1.0	2.514
1.1	2.994
1.2	3.461
1.3	3.908
1.4	4.332
1.5	4.733
1.6	5.111
1.7	5.467
1.8	5.802
1.9	6.119
2.0	6.416
2.1	6.697
2.2	6.961
2.3	7.210
2.4	7.444
2.5	7.663
2.6	7.869
2.7	8.062
2.8	8.242
2.9	8.409
3.0	8.565
3.1	8.710
3.2	8.844
3.3	8.968
3.4	9.082
3.5	9.186
3.6	9.281
3.7	9.367
3.8	9.445
3.9	9.516
4.0	9.578

Station Description	
Station:	DURONIA
Station Code:	DUI
Latitude:	41°39′32.4″N
Longitude:	14°27′28.8″E
Elevation:	918 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	66 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	1980
Date off:	
Comments:	

DUI Duronia 1992-4-8



Station DUI
Short period response (poles and zeros)

CAL1 DUI

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

DURONIA, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=1089.15 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

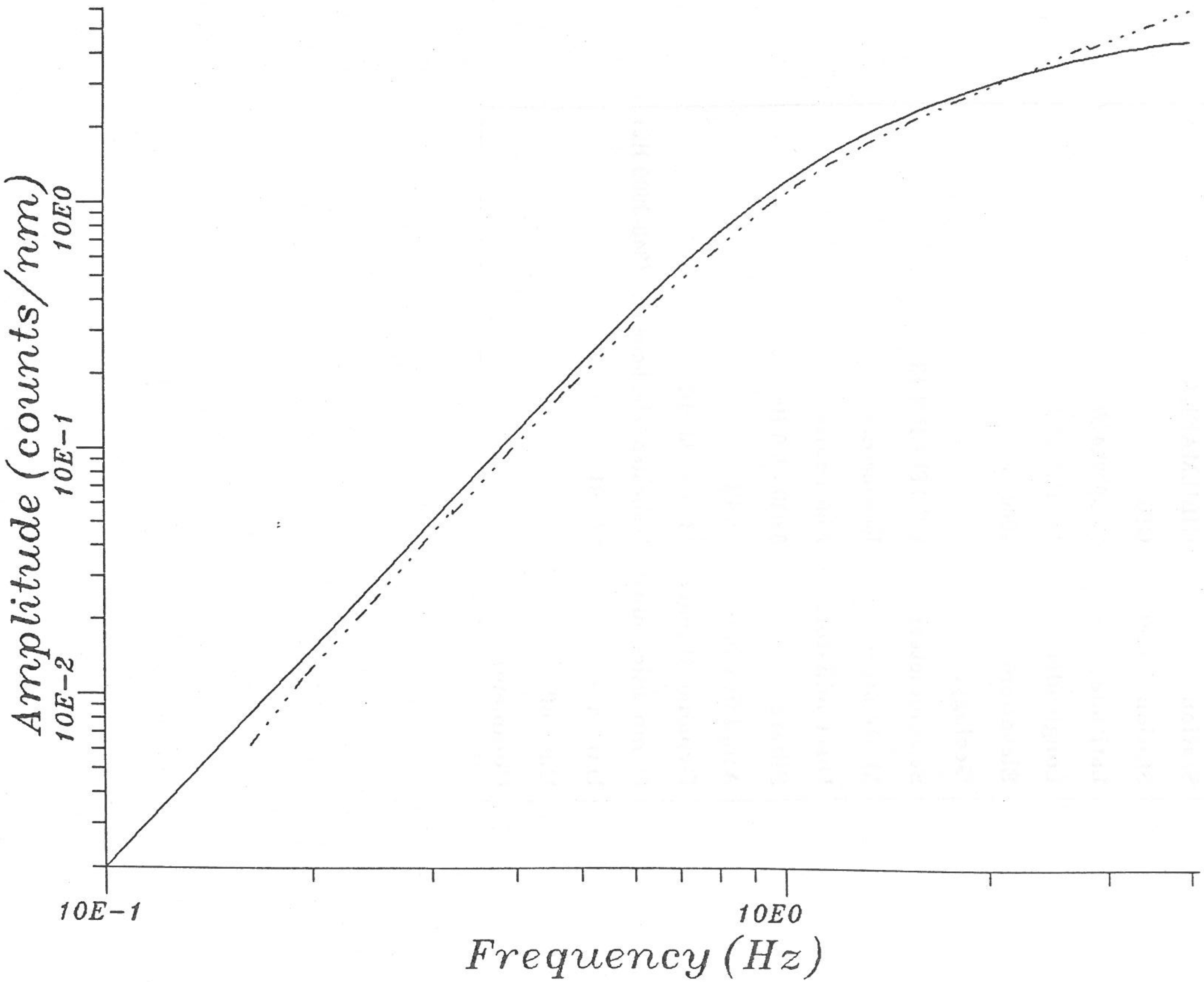
DURONIA

1992-4-8

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.006
0.2	0.054
0.3	0.182
0.4	0.423
0.5	0.801
0.6	1.323
0.7	1.975
0.8	2.729
0.9	3.546
1.0	4.388
1.1	5.227
1.2	6.041
1.3	6.822
1.4	7.562
1.5	8.262
1.6	8.921
1.7	9.543
1.8	10.129
1.9	10.681
2.0	11.201
2.1	11.691
2.2	12.152
2.3	12.586
2.4	12.994
2.5	13.377
2.6	13.736
2.7	14.073
2.8	14.387
2.9	14.680
3.0	14.952
3.1	15.205
3.2	15.439
3.3	15.655
3.4	15.853
3.5	16.035
3.6	16.201
3.7	16.352
3.8	16.488
3.9	16.611
4.0	16.720

Station Description	
Station:	GIBILMANNA
Station Code:	GIB
Latitude:	37°59'20.4"N
Longitude:	14° 1'37.2"E
Elevation:	1000 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	54 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	1/1981
Date off:	
Comments:	

GIB Gibilmanna 1991–9–18



Station GIB
Short period response (poles and zeros)

CAL1 GIB

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

GIBILMANNA, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=297.20 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

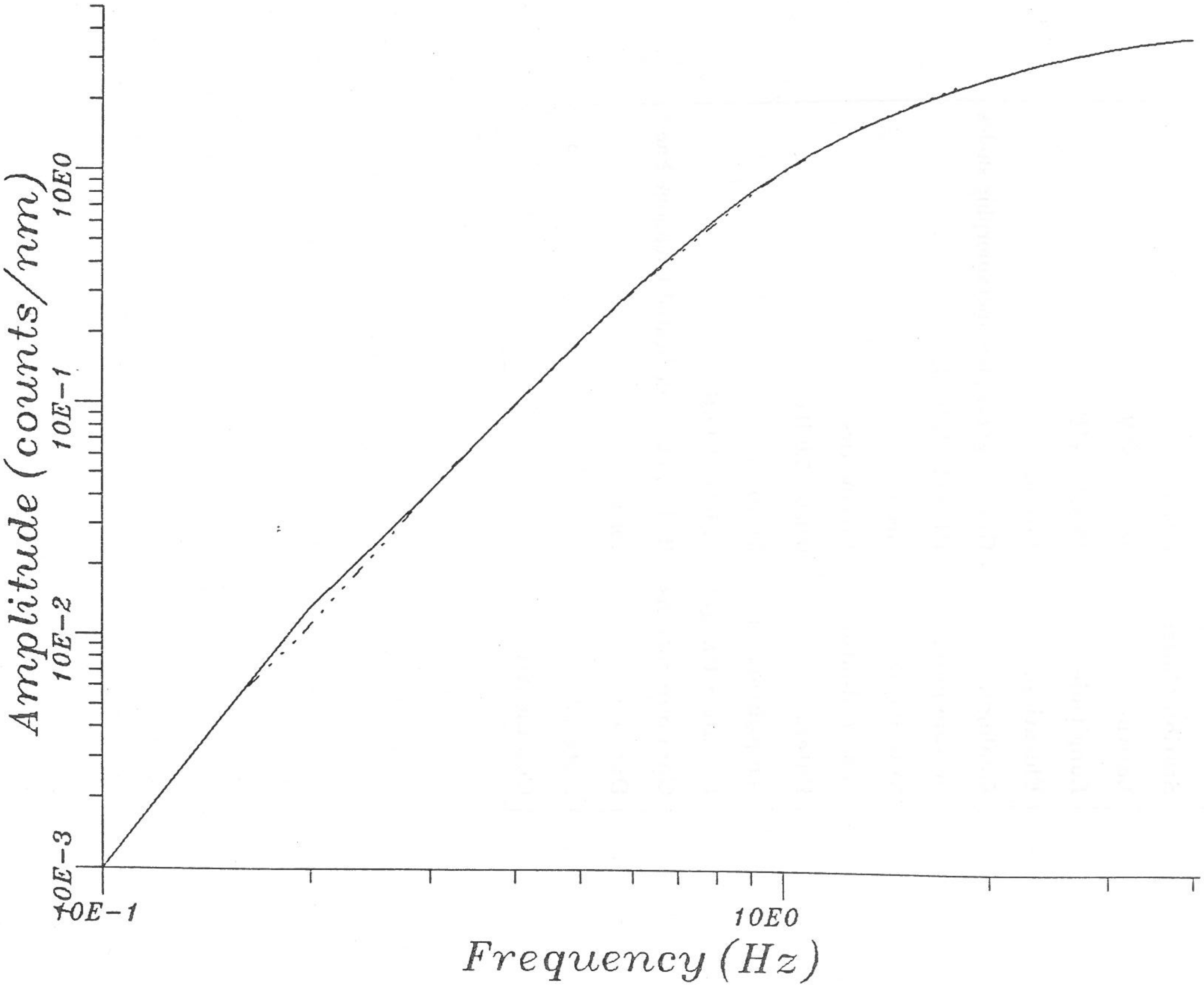
GIBILMANNA

1991-9-18

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.002
0.2	0.015
0.3	0.050
0.4	0.115
0.5	0.219
0.6	0.361
0.7	0.539
0.8	0.745
0.9	0.968
1.0	1.197
1.1	1.426
1.2	1.649
1.3	1.861
1.4	2.063
1.5	2.254
1.6	2.434
1.7	2.604
1.8	2.764
1.9	2.914
2.0	3.056
2.1	3.190
2.2	3.316
2.3	3.434
2.4	3.546
2.5	3.650
2.6	3.748
2.7	3.840
2.8	3.926
2.9	4.006
3.0	4.080
3.1	4.149
3.2	4.213
3.3	4.272
3.4	4.326
3.5	4.376
3.6	4.421
3.7	4.462
3.8	4.499
3.9	4.533
4.0	4.562

Station Description	
Station:	GAMBARIE
Station Code:	GMB
Latitude:	$38°10'\ 4.8''N$
Longitude:	$15°49'44.4''E$
Elevation:	1310 m
Geology:	Granite, gneiss, low metamorphic shales
Seismometer:	GEOTECH S-13
Modulator:	Geotech
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	54 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Radio links + dedicated telephone line
Date on:	1986
Date off:	
Comments:	

GMB Gambarie 1991-2-28



Station GMB
Short period response (poles and zeros)

CAL1 GMB

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

GAMBARIE, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=254.38 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER
DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

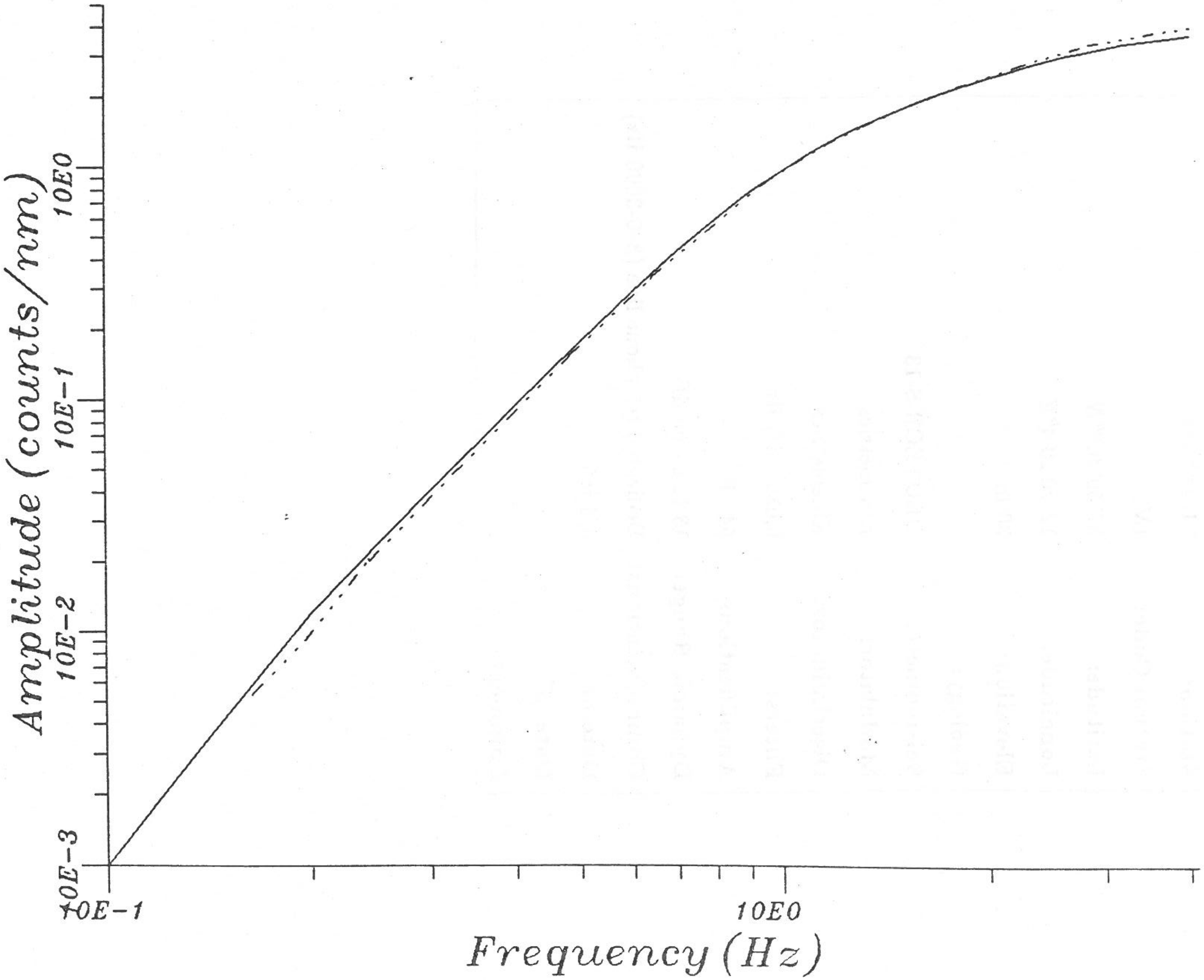
GAMBARIE

1991-2-28

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.001
0.2	0.013
0.3	0.042
0.4	0.099
0.5	0.187
0.6	0.309
0.7	0.461
0.8	0.637
0.9	0.828
1.0	1.025
1.1	1.221
1.2	1.411
1.3	1.593
1.4	1.766
1.5	1.930
1.6	2.084
1.7	2.229
1.8	2.366
1.9	2.495
2.0	2.616
2.1	2.730
2.2	2.838
2.3	2.940
2.4	3.035
2.5	3.124
2.6	3.208
2.7	3.287
2.8	3.360
2.9	3.428
3.0	3.492
3.1	3.551
3.2	3.606
3.3	3.656
3.4	3.703
3.5	3.745
3.6	3.784
3.7	3.819
3.8	3.851
3.9	3.879
4.0	3.905

Station Description	
Station:	LEVANZO
Station Code:	LVI
Latitude:	37°59′ 9.6″N
Longitude:	12°20′20.4″E
Elevation:	30 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	54 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	5/1985
Date off:	
Comments:	

LVI Levanzo 1992-2-3



Station LVI
Short period response (poles and zeros)

CAL1 LVI

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

LEVANZO, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=245.25 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

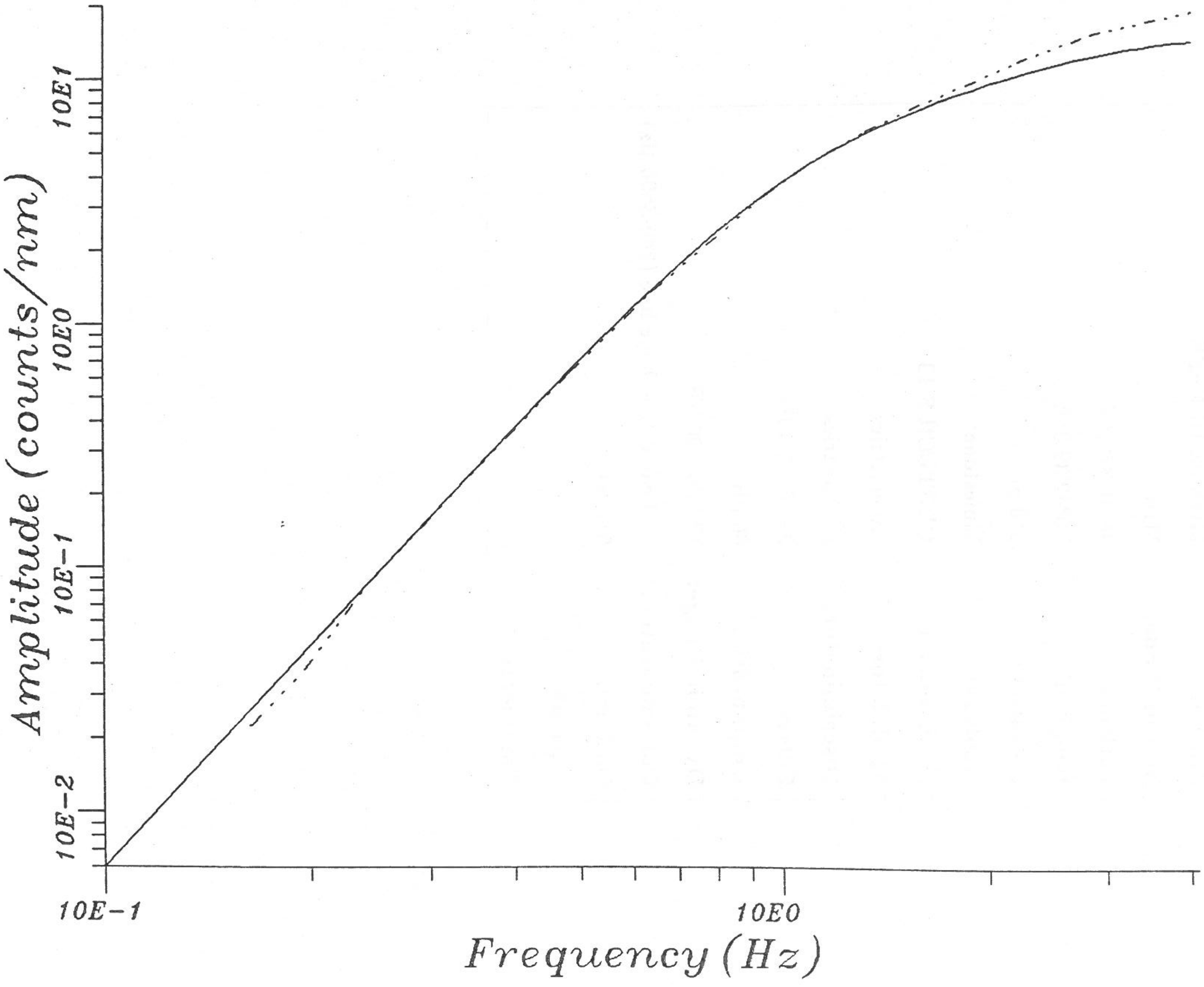
LEVANZO

1992-2-3

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.001
0.2	0.012
0.3	0.041
0.4	0.095
0.5	0.180
0.6	0.298
0.7	0.445
0.8	0.615
0.9	0.798
1.0	0.988
1.1	1.177
1.2	1.360
1.3	1.536
1.4	1.703
1.5	1.860
1.6	2.009
1.7	2.149
1.8	2.281
1.9	2.405
2.0	2.522
2.1	2.632
2.2	2.736
2.3	2.834
2.4	2.926
2.5	3.012
2.6	3.093
2.7	3.169
2.8	3.239
2.9	3.305
3.0	3.367
3.1	3.424
3.2	3.476
3.3	3.525
3.4	3.570
3.5	3.611
3.6	3.648
3.7	3.682
3.8	3.713
3.9	3.740
4.0	3.765

Station Description	
Station:	MONTE DI NESE
Station Code:	MDI
Latitude:	$45°46'37.2''N$
Longitude:	$9°42'39.6''E$
Elevation:	910 m
Geology:	Limestone
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	66 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	5/1984
Date off:	
Comments:	

MDI Monte di Nese 1992-6-22



Station MDI
Short period response (poles and zeros)

CAL1 MDI

```
        6
   -0.188      0.0
   -0.188      0.0
   -4.769     -4.09
   -4.769     +4.09
   -31.4       0.0
   -31.4       0.0
       5
   -0.0        0.0
   -0.0        0.0
   -0.0        0.0
   -0.0        0.0
   -0.0        0.0
```

MONTE DI NESE, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=970.45 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER
DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

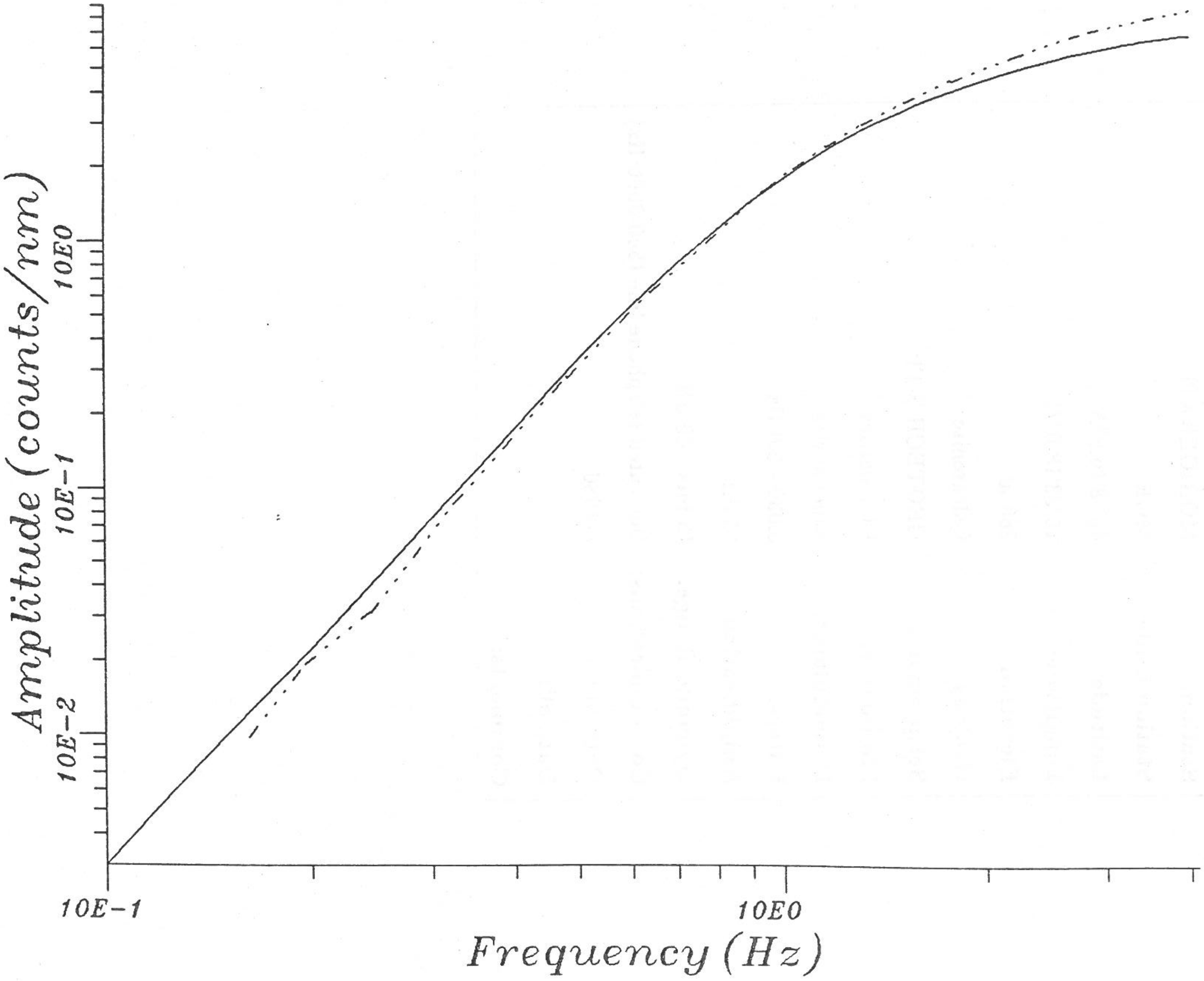
MONTE DI NESE

1992-6-22

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.006
0.2	0.048
0.3	0.162
0.4	0.377
0.5	0.714
0.6	1.179
0.7	1.760
0.8	2.432
0.9	3.159
1.0	3.910
1.1	4.657
1.2	5.383
1.3	6.078
1.4	6.738
1.5	7.361
1.6	7.949
1.7	8.503
1.8	9.025
1.9	9.517
2.0	9.980
2.1	10.417
2.2	10.828
2.3	11.214
2.4	11.578
2.5	11.919
2.6	12.239
2.7	12.539
2.8	12.819
2.9	13.080
3.0	13.323
3.1	13.548
3.2	13.756
3.3	13.949
3.4	14.126
3.5	14.288
3.6	14.436
3.7	14.570
3.8	14.691
3.9	14.800
4.0	14.898

Station Description	
Station:	MORIGERATI
Station Code:	MGR
Latitude:	40° 8′16.8″N
Longitude:	15°33′18.0″E
Elevation:	260 m
Geology:	Calcarenite
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Demodulator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	60 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	1/1986
Date off:	
Comments:	

MGR Morigerati 1992-8-6



Station MGR
Short period response (poles and zeros)

CAL1 MGR

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

MORIGERATI, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=447.71 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER
DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

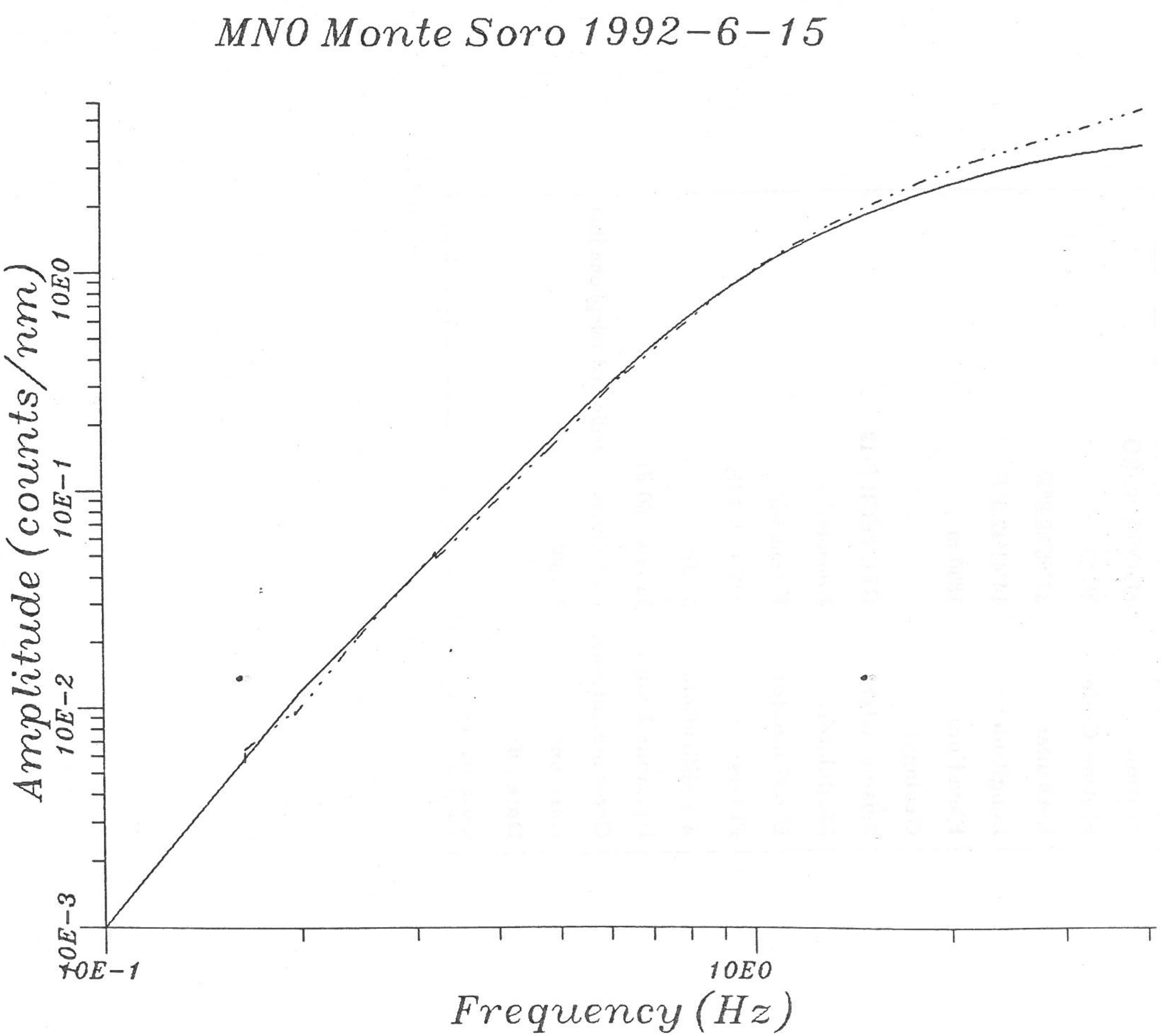
Short Period Response Data

MORIGERATI

1992-8-6

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.003
0.2	0.022
0.3	0.075
0.4	0.174
0.5	0.329
0.6	0.544
0.7	0.812
0.8	1.122
0.9	1.457
1.0	1.804
1.1	2.148
1.2	2.483
1.3	2.804
1.4	3.108
1.5	3.396
1.6	3.667
1.7	3.923
1.8	4.164
1.9	4.390
2.0	4.604
2.1	4.806
2.2	4.995
2.3	5.174
2.4	5.341
2.5	5.499
2.6	5.647
2.7	5.785
2.8	5.914
2.9	6.034
3.0	6.146
3.1	6.250
3.2	6.346
3.3	6.435
3.4	6.517
3.5	6.592
3.6	6.660
3.7	6.722
3.8	6.778
3.9	6.828
4.0	6.873

Station Description	
Station:	MONTE SORO
Station Code:	MNO
Latitude:	37°55′58.8″*N*
Longitude:	14°41′42.0″*E*
Elevation:	1830 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	54 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Radio links + dedicated telephone line
Date on:	8/1986
Date off:	
Comments:	


MNO Monte Soro 1992−6−15
Amplitude (counts/nm)
10E−3
10E−2
10E−1
10E0
10E−1
10E0
Frequency (Hz)

Station MNO
Short period response (poles and zeros)

CAL1 MNO

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

MONTE SORO, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=246.39 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER
DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

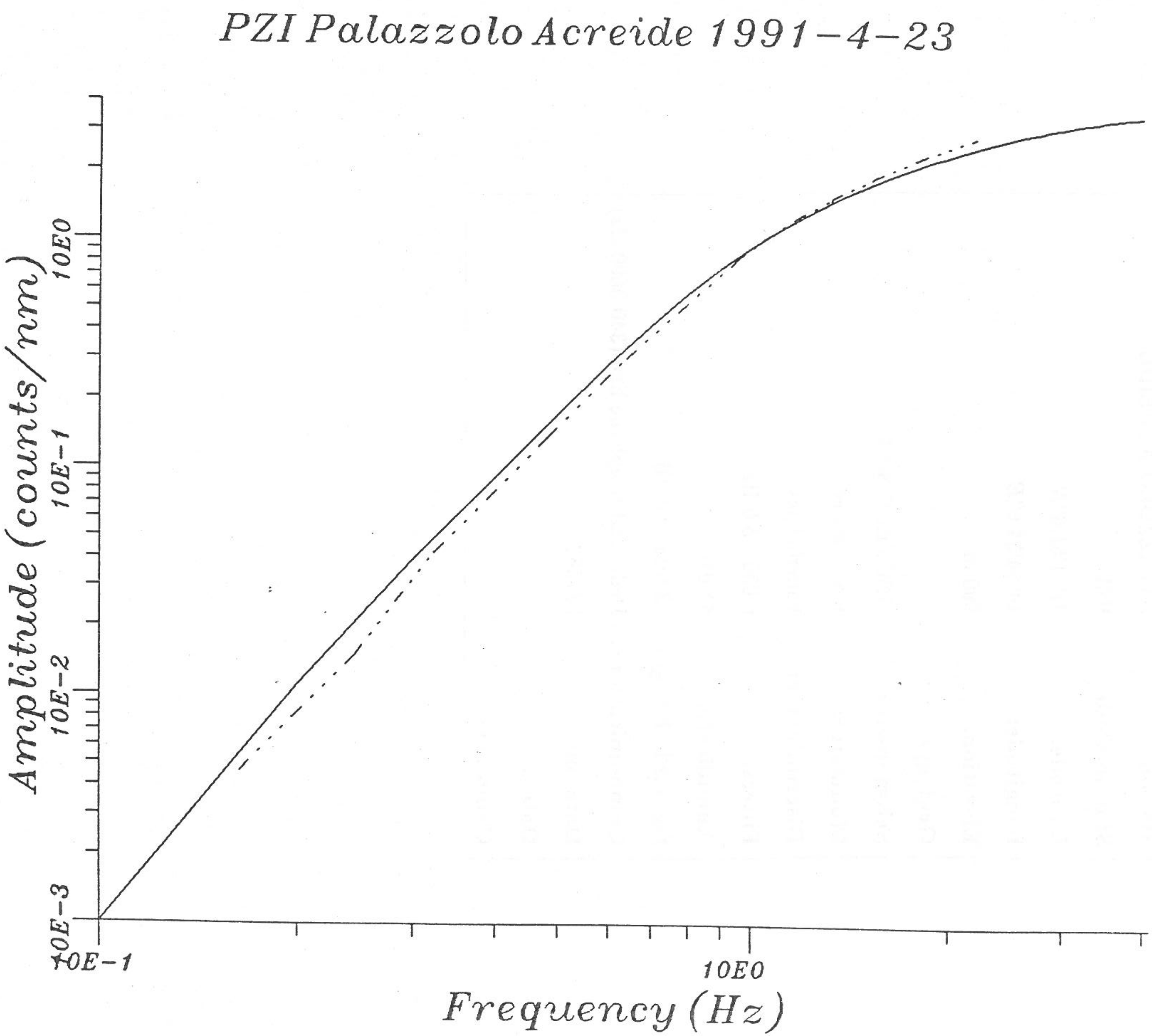
Short Period Response Data

MONTE SORO

1992-6-15

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.001
0.2	0.012
0.3	0.041
0.4	0.096
0.5	0.181
0.6	0.299
0.7	0.447
0.8	0.617
0.9	0.802
1.0	0.993
1.1	1.182
1.2	1.367
1.3	1.543
1.4	1.711
1.5	1.869
1.6	2.018
1.7	2.159
1.8	2.291
1.9	2.416
2.0	2.534
2.1	2.645
2.2	2.749
2.3	2.847
2.4	2.940
2.5	3.026
2.6	3.107
2.7	3.184
2.8	3.255
2.9	3.321
3.0	3.382
3.1	3.440
3.2	3.493
3.3	3.541
3.4	3.586
3.5	3.628
3.6	3.665
3.7	3.699
3.8	3.730
3.9	3.758
4.0	3.782

Station Description	
Station:	PALAZZOLO ACREIDE
Station Code:	PZI
Latitude:	37° 1′51.6″N
Longitude:	14°54′54.0″E
Elevation:	690 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	54 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	9/1983
Date off:	
Comments:	



PZI Palazzolo Acreide 1991-4-23
Amplitude (counts/nm)
10E0
10E-1
10E-2
10E-3
10E-1
10E0
Frequency (Hz)

Station PZI
Short period response (poles and zeros)

CAL1 PZI

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

PALAZZOLO ACREIDE, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=231.53 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER
DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

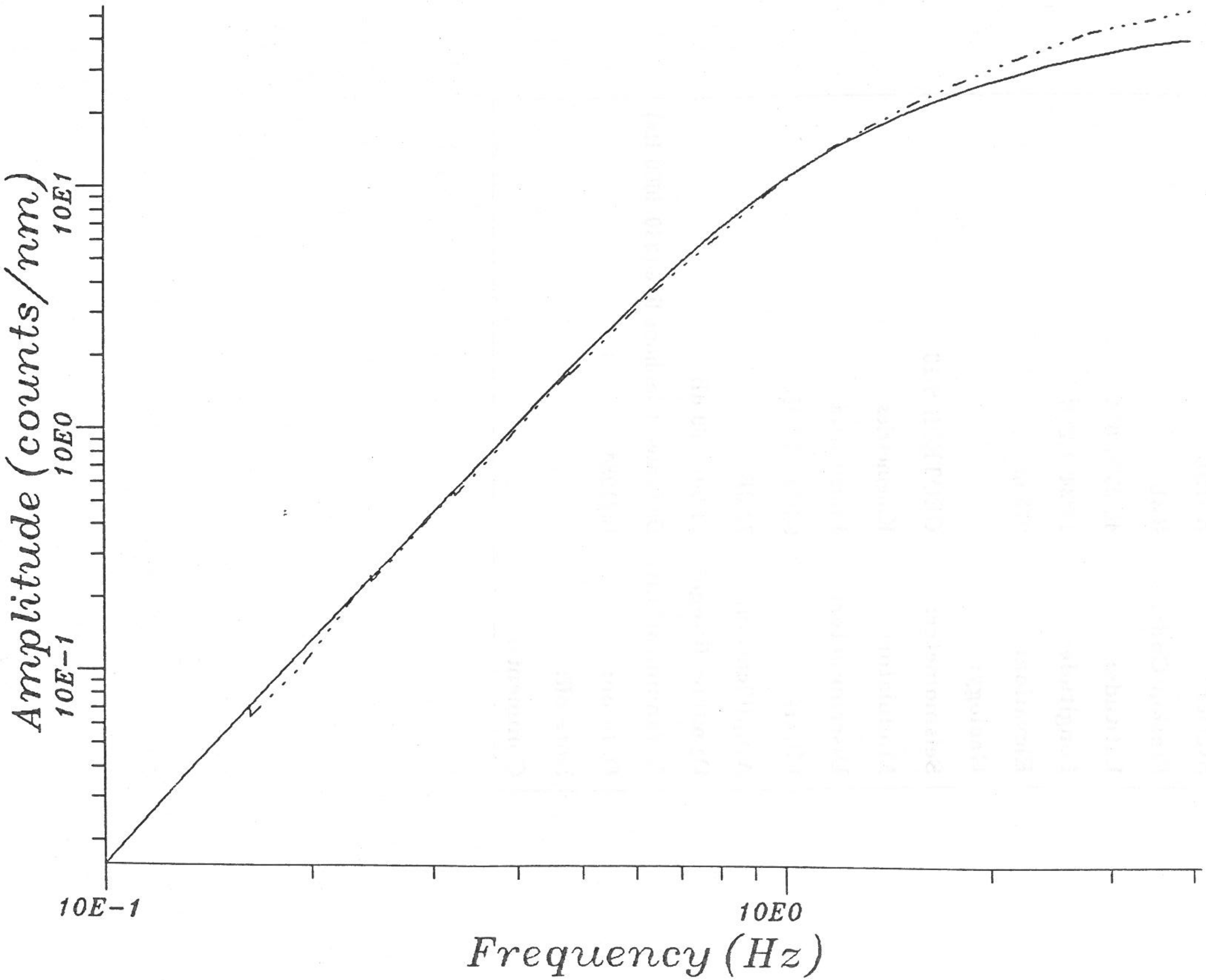
PALAZZOLO ACREIDE

1991-4-23

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.001
0.2	0.011
0.3	0.039
0.4	0.090
0.5	0.170
0.6	0.281
0.7	0.420
0.8	0.580
0.9	0.754
1.0	0.933
1.1	1.111
1.2	1.284
1.3	1.450
1.4	1.608
1.5	1.756
1.6	1.896
1.7	2.029
1.8	2.153
1.9	2.271
2.0	2.381
2.1	2.485
2.2	2.583
2.3	2.676
2.4	2.762
2.5	2.844
2.6	2.920
2.7	2.992
2.8	3.058
2.9	3.121
3.0	3.179
3.1	3.232
3.2	3.282
3.3	3.328
3.4	3.370
3.5	3.409
3.6	3.444
3.7	3.476
3.8	3.505
3.9	3.531
4.0	3.554

Station Description	
Station:	RAIBL
Station Code:	RBL
Latitude:	$46°26'27.6''N$
Longitude:	$13°34'\ 1.2''E$
Elevation:	975 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	72 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	10/1984
Date off:	
Comments:	

RBL Raibl 1991-12-3



Station RBL
Short period response (poles and zeros)

CAL1 RBL

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

RAIBL, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=2695.33 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

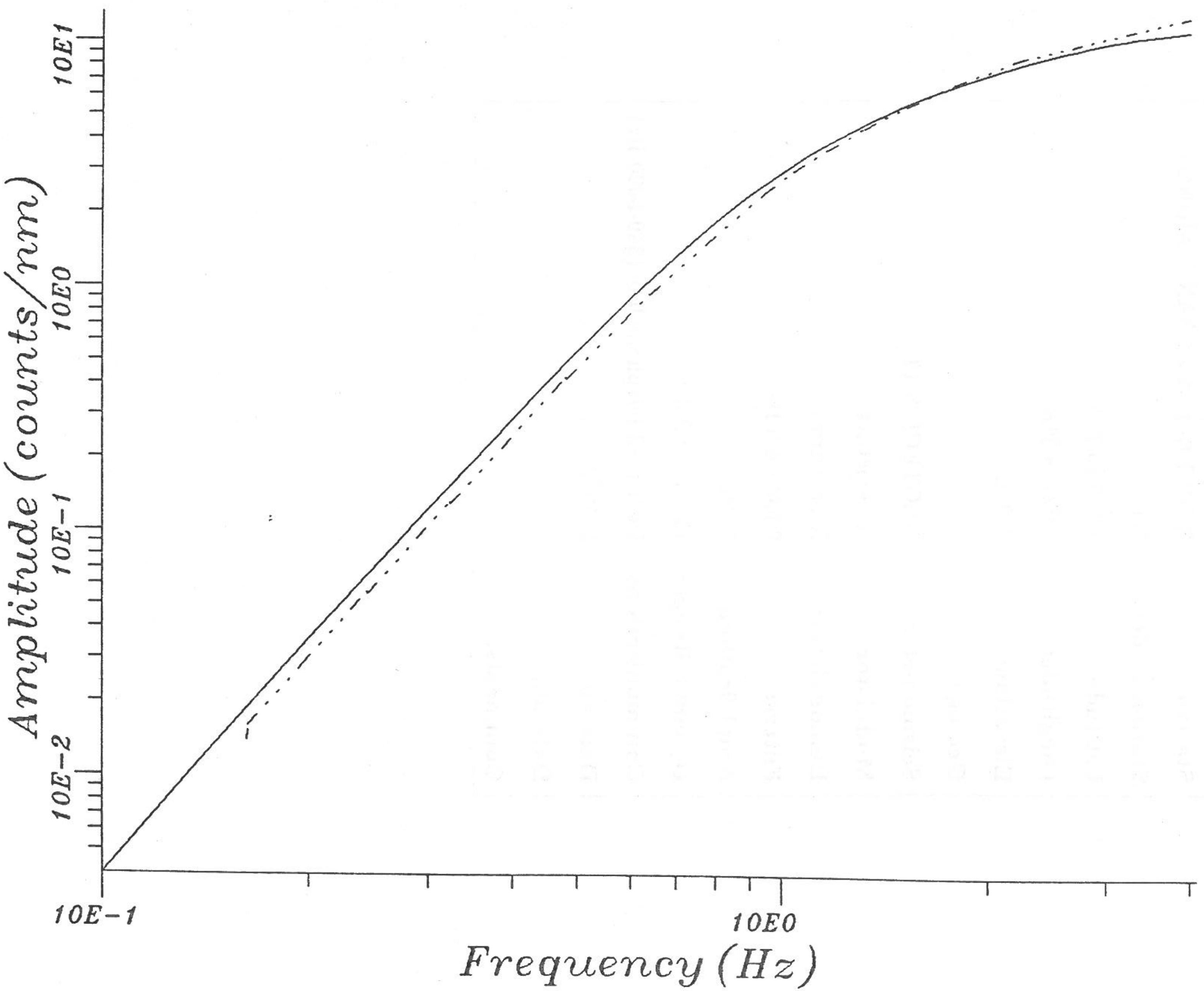
RAIBL

1991-12-3

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.016
0.2	0.133
0.3	0.449
0.4	1.047
0.5	1.983
0.6	3.274
0.7	4.889
0.8	6.754
0.9	8.774
1.0	10.859
1.1	12.934
1.2	14.951
1.3	16.881
1.4	18.714
1.5	20.445
1.6	22.077
1.7	23.616
1.8	25.066
1.9	26.431
2.0	27.718
2.1	28.931
2.2	30.072
2.3	31.147
2.4	32.156
2.5	33.104
2.6	33.993
2.7	34.825
2.8	35.603
2.9	36.328
3.0	37.002
3.1	37.628
3.2	38.207
3.3	38.741
3.4	39.232
3.5	39.683
3.6	40.093
3.7	40.467
3.8	40.804
3.9	41.107
4.0	41.377

Station Description	
Station:	REPUBBLICA DI SAN MARINO
Station Code:	RSM
Latitude:	43°55′39.7″N
Longitude:	12°27′ 8.3″E
Elevation:	600 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Demodulator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	54 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	3/1988
Date off:	
Comments:	

RSM Rep. S. Marino 1991–12–5



Station RSM
Short period response (poles and zeros)

CAL1 RSM

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

REPUBBLICA DI SAN MARINO, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=738.87 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER
DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

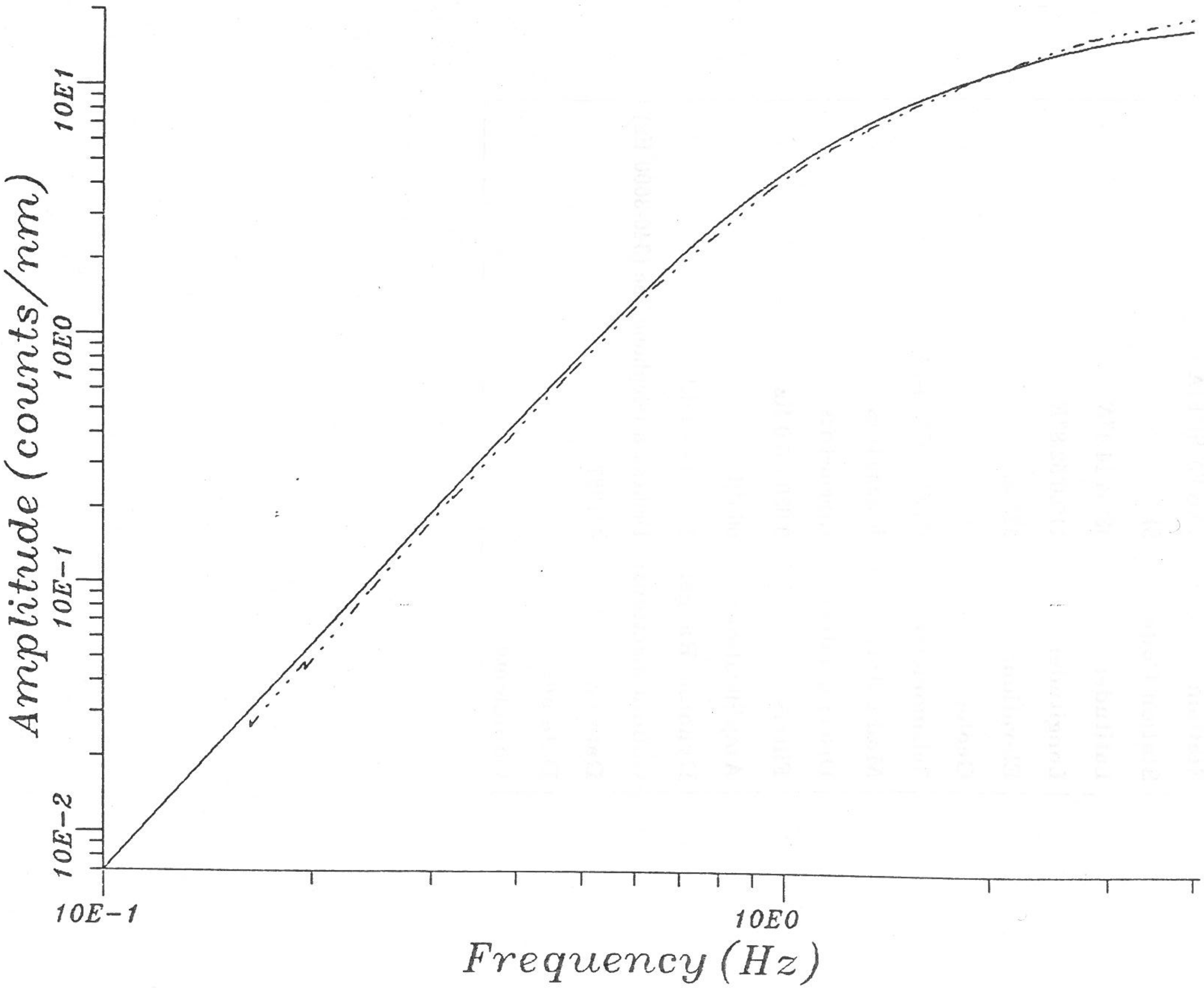
REP S. MARINO

1991-12-5

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.004
0.2	0.036
0.3	0.123
0.4	0.287
0.5	0.544
0.6	0.898
0.7	1.340
0.8	1.851
0.9	2.405
1.0	2.977
1.1	3.546
1.2	4.098
1.3	4.628
1.4	5.130
1.5	5.605
1.6	6.052
1.7	6.474
1.8	6.871
1.9	7.246
2.0	7.598
2.1	7.931
2.2	8.244
2.3	8.538
2.4	8.815
2.5	9.075
2.6	9.319
2.7	9.547
2.8	9.760
2.9	9.958
3.0	10.143
3.1	10.315
3.2	10.474
3.3	10.620
3.4	10.755
3.5	10.878
3.6	10.991
3.7	11.093
3.8	11.185
3.9	11.269
4.0	11.343

Station Description	
Station:	SANTA SOFIA
Station Code:	SFI
Latitude:	43°54′14.4″*N*
Longitude:	11°50′52.8″*E*
Elevation:	525 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	66 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	4/1987
Date off:	
Comments:	

SFI S. Sofia 1992-9-25



Station SFI
Short period response (poles and zeros)

CAL1 SFI

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

SANTA SOFIA, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=1140.44 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

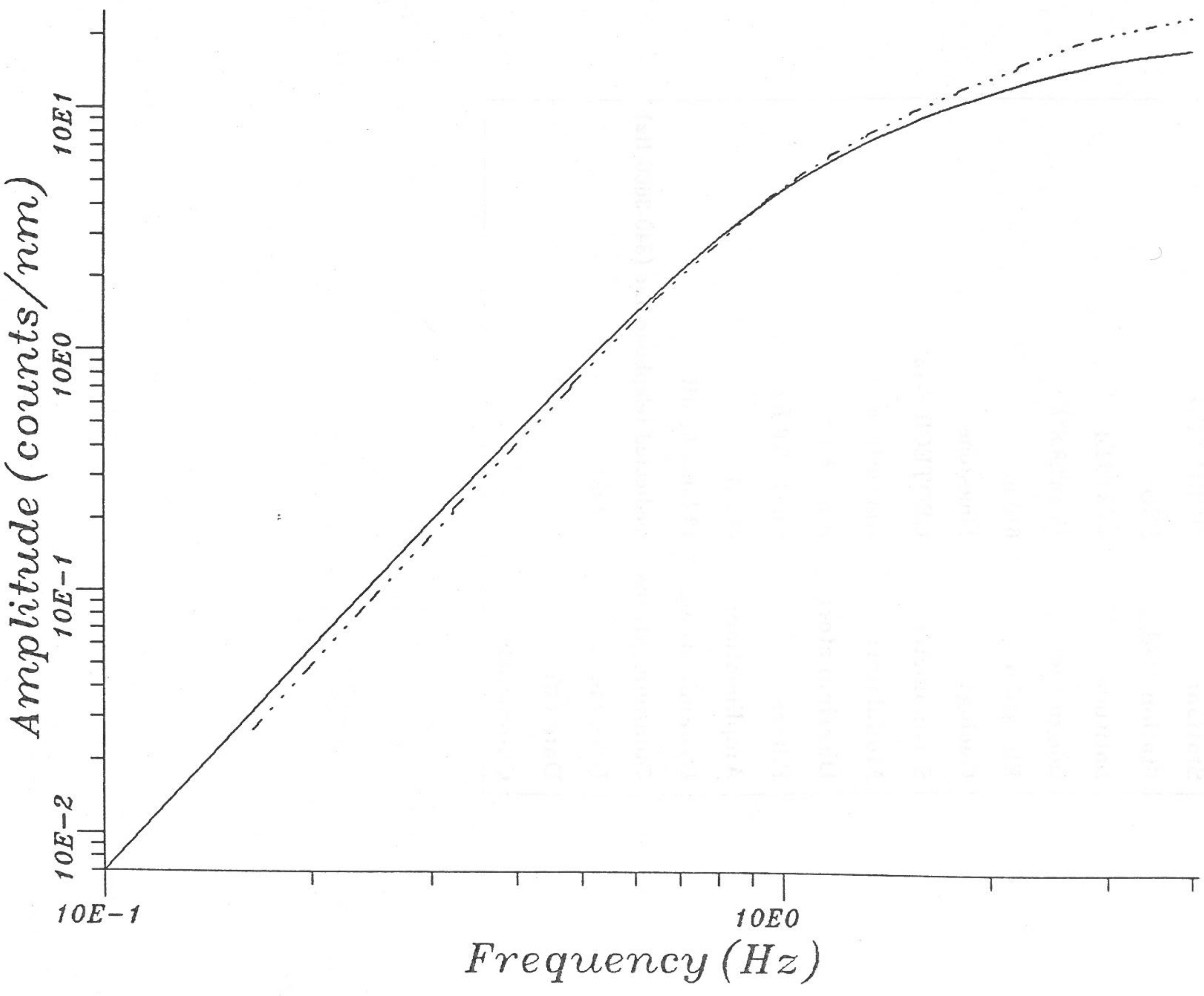
SANTA SOFIA

1992-9-25

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.007
0.2	0.056
0.3	0.190
0.4	0.443
0.5	0.839
0.6	1.385
0.7	2.069
0.8	2.858
0.9	3.713
1.0	4.595
1.1	5.473
1.2	6.326
1.3	7.143
1.4	7.918
1.5	8.651
1.6	9.341
1.7	9.992
1.8	10.606
1.9	11.184
2.0	11.728
2.1	12.241
2.2	12.724
2.3	13.179
2.4	13.606
2.5	14.007
2.6	14.383
2.7	14.735
2.8	15.064
2.9	15.371
3.0	15.656
3.1	15.921
3.2	16.166
3.3	16.392
3.4	16.600
3.5	16.790
3.6	16.964
3.7	17.122
3.8	17.265
3.9	17.393
4.0	17.507

Station Description	
Station:	SICIGNANO
Station Code:	SGO
Latitude:	40°33′32.4″N
Longitude:	15°18′28.8″E
Elevation:	610 m
Geology:	Limestone
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	66 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	1/1981
Date off:	
Comments:	

SGO Sicignano 1992-1-27



Station SGO
Short period response (poles and zeros)

CAL1 SGO

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

SICIGNANO, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=1171.33 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

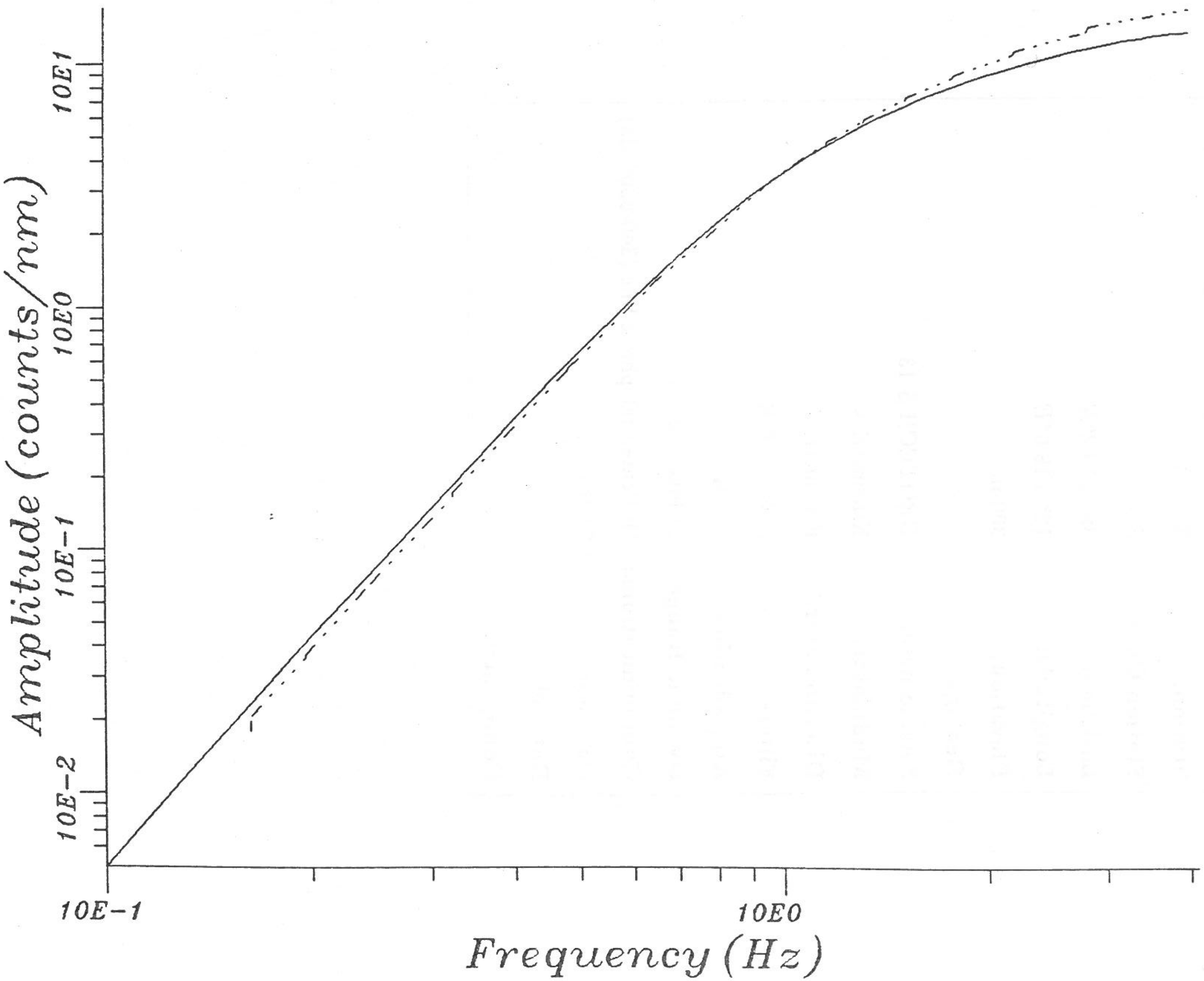
SICIGNANO

1992-1-27

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.007
0.2	0.058
0.3	0.195
0.4	0.455
0.5	0.862
0.6	1.423
0.7	2.125
0.8	2.935
0.9	3.813
1.0	4.719
1.1	5.621
1.2	6.497
1.3	7.336
1.4	8.133
1.5	8.885
1.6	9.594
1.7	10.263
1.8	10.893
1.9	11.487
2.0	12.046
2.1	12.573
2.2	13.069
2.3	13.536
2.4	13.975
2.5	14.387
2.6	14.773
2.7	15.134
2.8	15.472
2.9	15.787
3.0	16.080
3.1	16.352
3.2	16.604
3.3	16.836
3.4	17.050
3.5	17.245
3.6	17.424
3.7	17.586
3.8	17.732
3.9	17.864
4.0	17.981

Station Description	
Station:	SAMO
Station Code:	SOI
Latitude:	38° 4′19.2″N
Longitude:	16° 3′18.0″E
Elevation:	300 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	66 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	3/1986
Date off:	
Comments:	

SOI Samo 1992-1-17



Station SOI
Short period response (poles and zeros)

CAL1 SOI

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

SAMO, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=888.98 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

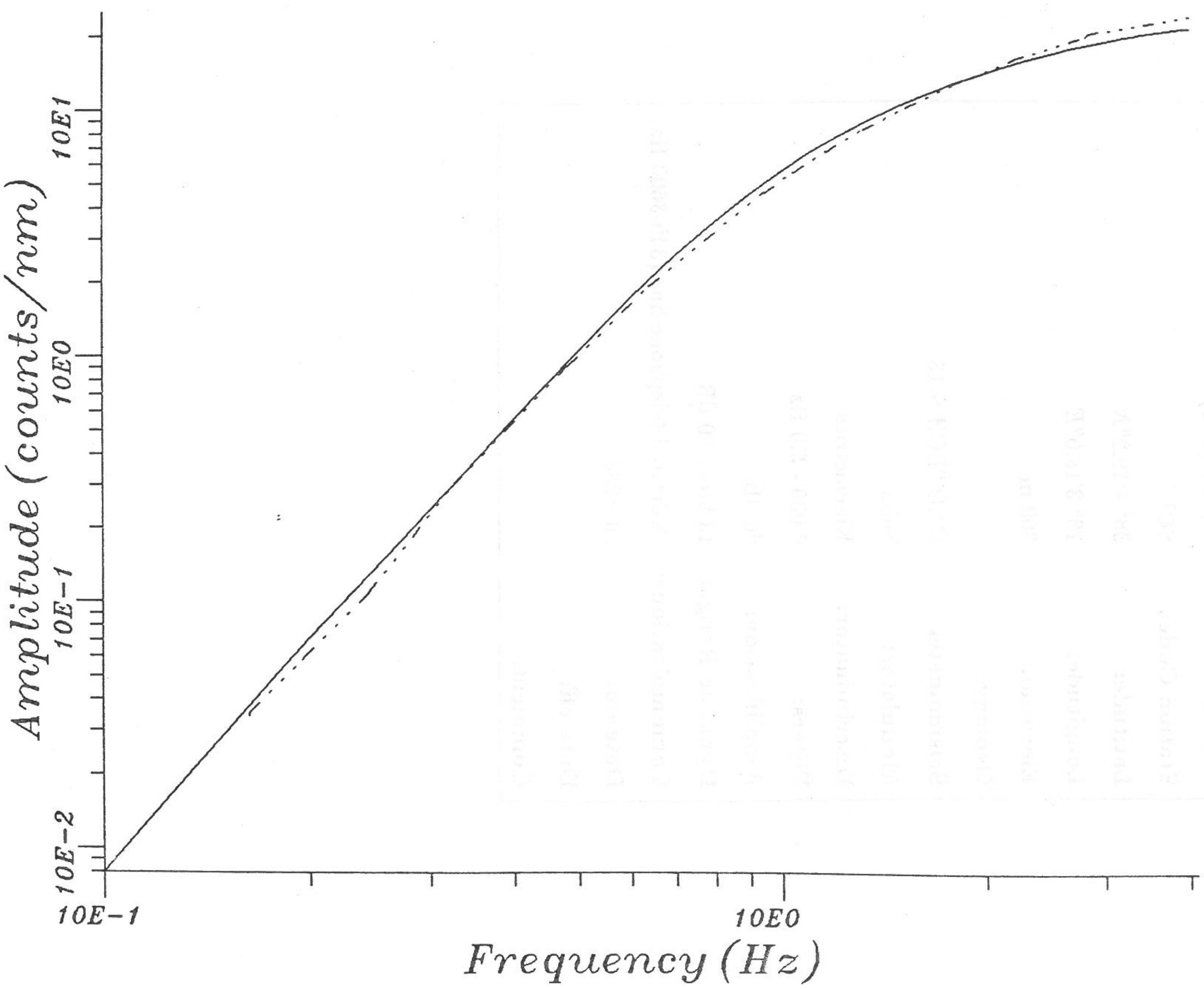
SAMO

1992-1-17

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.005
0.2	0.044
0.3	0.148
0.4	0.345
0.5	0.654
0.6	1.080
0.7	1.612
0.8	2.227
0.9	2.894
1.0	3.582
1.1	4.266
1.2	4.931
1.3	5.568
1.4	6.172
1.5	6.743
1.6	7.282
1.7	7.789
1.8	8.267
1.9	8.718
2.0	9.142
2.1	9.542
2.2	9.919
2.3	10.273
2.4	10.606
2.5	10.919
2.6	11.212
2.7	11.486
2.8	11.743
2.9	11.982
3.0	12.204
3.1	12.410
3.2	12.601
3.3	12.778
3.4	12.940
3.5	13.088
3.6	13.224
3.7	13.347
3.8	13.458
3.9	13.558
4.0	13.647

Station Description	
Station:	SAMO (N-S)
Station Code:	SOIN
Latitude:	38° 4′19.2″N
Longitude:	16° 3′18.0″E
Elevation:	300 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Saba
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	66 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	10/1988
Date off:	
Comments:	

SOI Samo (N–S) 1992–1–16



Station SOIN
Short period response (poles and zeros)

```
CAL1 SOIN

        6
  -0.188      0.0
  -0.188      0.0
  -4.769     -4.09
  -4.769     +4.09
  -31.4       0.0
  -31.4       0.0
        5
  -0.0        0.0
  -0.0        0.0
  -0.0        0.0
  -0.0        0.0
  -0.0        0.0
SAMO (N-S), ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=1428.61 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER
     DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.
```

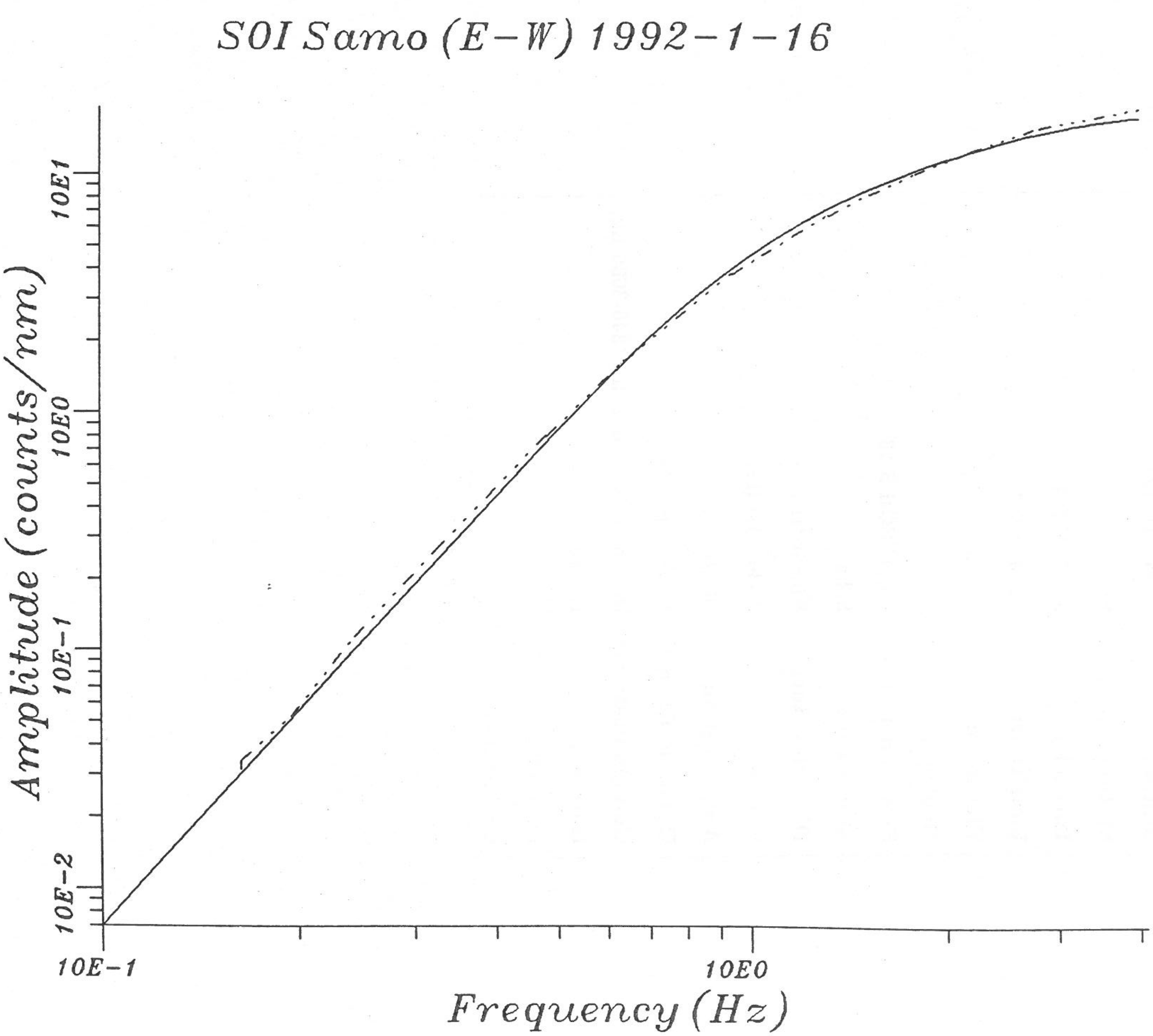
Short Period Response Data

SAMO N-S

1992-1-16

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.008
0.2	0.071
0.3	0.238
0.4	0.555
0.5	1.051
0.6	1.736
0.7	2.591
0.8	3.580
0.9	4.651
1.0	5.756
1.1	6.856
1.2	7.924
1.3	8.948
1.4	9.919
1.5	10.836
1.6	11.702
1.7	12.517
1.8	13.286
1.9	14.010
2.0	14.692
2.1	15.334
2.2	15.939
2.3	16.509
2.4	17.044
2.5	17.546
2.6	18.018
2.7	18.459
2.8	18.871
2.9	19.255
3.0	19.612
3.1	19.944
3.2	20.251
3.3	20.534
3.4	20.794
3.5	21.033
3.6	21.251
3.7	21.449
3.8	21.627
3.9	21.788
4.0	21.931

Station Description	
Station:	SAMO (E-W)
Station Code:	SOIE
Latitude:	38° 4′19.2″N
Longitude:	16° 3′18.0″E
Elevation:	300 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Saba
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	66 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	10/1988
Date off:	
Comments:	


SOI Samo (E−W) 1992−1−16
10E1
10E0
10E−1
10E−2
Amplitude (counts/nm)
10E−1
10E0
Frequency (Hz)

Station SOIE
Short period response (poles and zeros)

CAL1 SOIE

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

SAMO (E-W), ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=1119.32 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER
DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

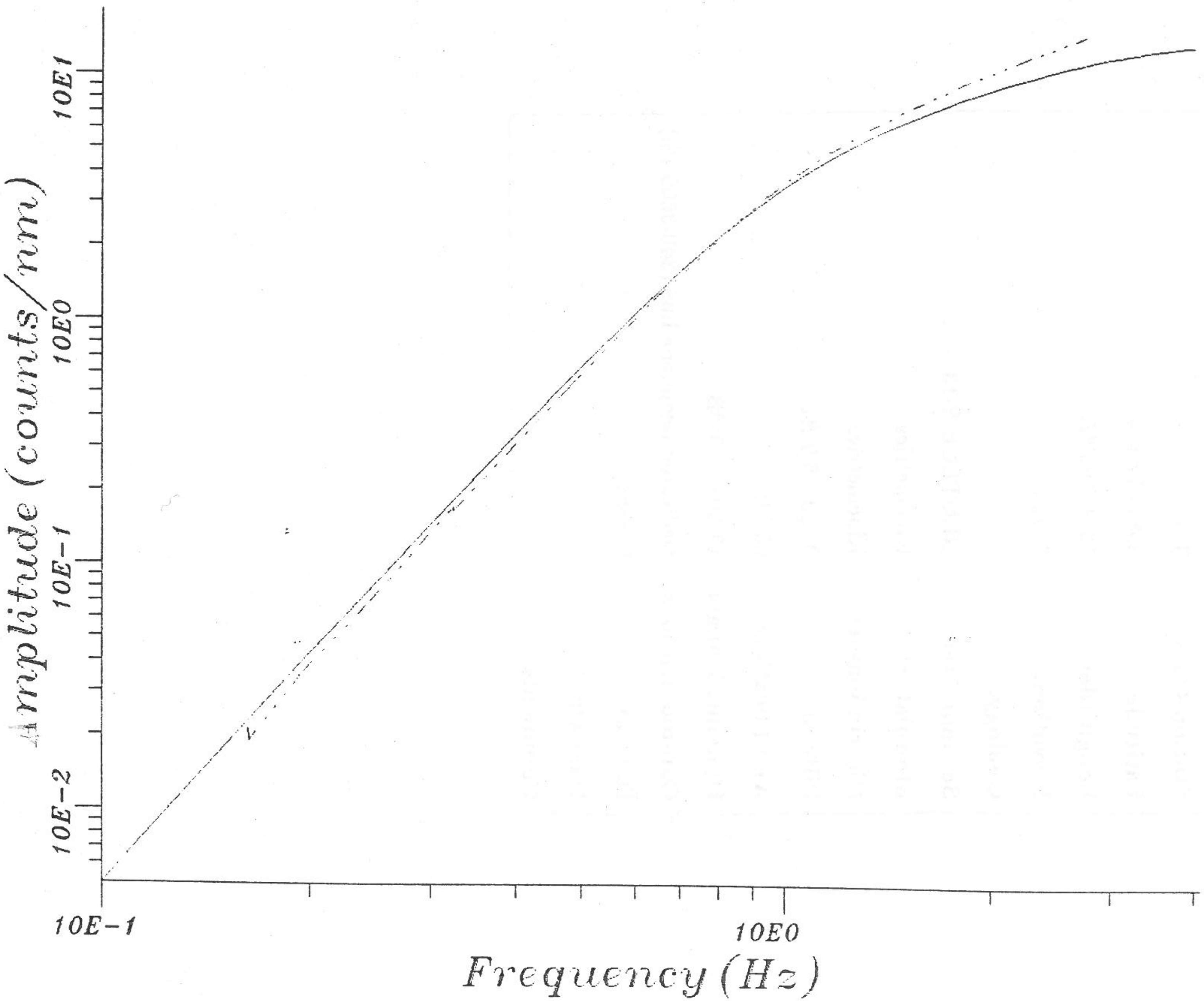
SAMO E-W

1992-1-16

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.007
0.2	0.055
0.3	0.187
0.4	0.435
0.5	0.824
0.6	1.360
0.7	2.030
0.8	2.805
0.9	3.644
1.0	4.510
1.1	5.371
1.2	6.209
1.3	7.010
1.4	7.771
1.5	8.490
1.6	9.168
1.7	9.807
1.8	10.409
1.9	10.976
2.0	11.511
2.1	12.014
2.2	12.489
2.3	12.935
2.4	13.354
2.5	13.748
2.6	14.117
2.7	14.462
2.8	14.785
2.9	15.086
3.0	15.366
3.1	15.626
3.2	15.866
3.3	16.088
3.4	16.292
3.5	16.479
3.6	16.650
3.7	16.805
3.8	16.945
3.9	17.071
4.0	17.183

Station Description	
Station:	TERRANOVA DI SIBARI
Station Code:	TDS
Latitude:	$39°39'32.4''N$
Longitude:	$16°20'16.8''E$
Elevation:	270 m
Geology:	
Seismometer:	GEOTECH S-13
Modulator:	Kinemetrics
Discriminator:	Kinemetrics
Filters:	0.030 - 5.0 Hz
Amplification:	66 dB
Dynamic Range:	13 bits - 60 dB
Communications:	Dedicated telephone line (340-3600 Hz)
Date on:	6/1984
Date off:	
Comments:	

TDS Terranova da Sibari 1991-11-5



Station TDS
Short period response (poles and zeros)

CAL1 TDS

6	
-0.188	0.0
-0.188	0.0
-4.769	-4.09
-4.769	+4.09
-31.4	0.0
-31.4	0.0
5	
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0
-0.0	0.0

TERRANOVA DI SIBARI, ITALY
SHORT-PERIOD VERTICAL INSTRUMENT DISPLACEMENT RESPONSE.
RESPONSE ABOVE IN POLES AND ZEROS.
D(W)=C * (S-Z1)(S-Z2)...(S-Z5)/((S-P1)(S-P2)...(S-P6)).
FOR S=JW WHERE W IS ANGULAR FREQUENCY AND J=SQRT(-1).
W=6.2383185F WHERE F IS ANGULAR FREQUENCY IN HZ.
C=873.47 NORMALSIZES SO THAT THE NUMBER OF NANOMETERS PER DIGITAL COUNT AT THE DESIRED FREQUENCY IS RETURNED.
END CALIBRATION SECTION.

Short Period Response Data

TERRANOVA DA SIBARI

1991-11-5

Frequency (Hz)	Amplitude (counts/nm)
0.1	0.005
0.2	0.043
0.3	0.146
0.4	0.339
0.5	0.643
0.6	1.061
0.7	1.584
0.8	2.189
0.9	2.844
1.0	3.519
1.1	4.192
1.2	4.845
1.3	5.471
1.4	6.064
1.5	6.626
1.6	7.155
1.7	7.653
1.8	8.123
1.9	8.566
2.0	8.983
2.1	9.376
2.2	9.746
2.3	10.094
2.4	10.421
2.5	10.728
2.6	11.016
2.7	11.286
2.8	11.538
2.9	11.773
3.0	11.991
3.1	12.194
3.2	12.382
3.3	12.555
3.4	12.714
3.5	12.860
3.6	12.993
3.7	13.114
3.8	13.223
3.9	13.321
4.0	13.409